SIMPLE
WIRE HF ANTENNA

OZAUKEE RADIO CLUB

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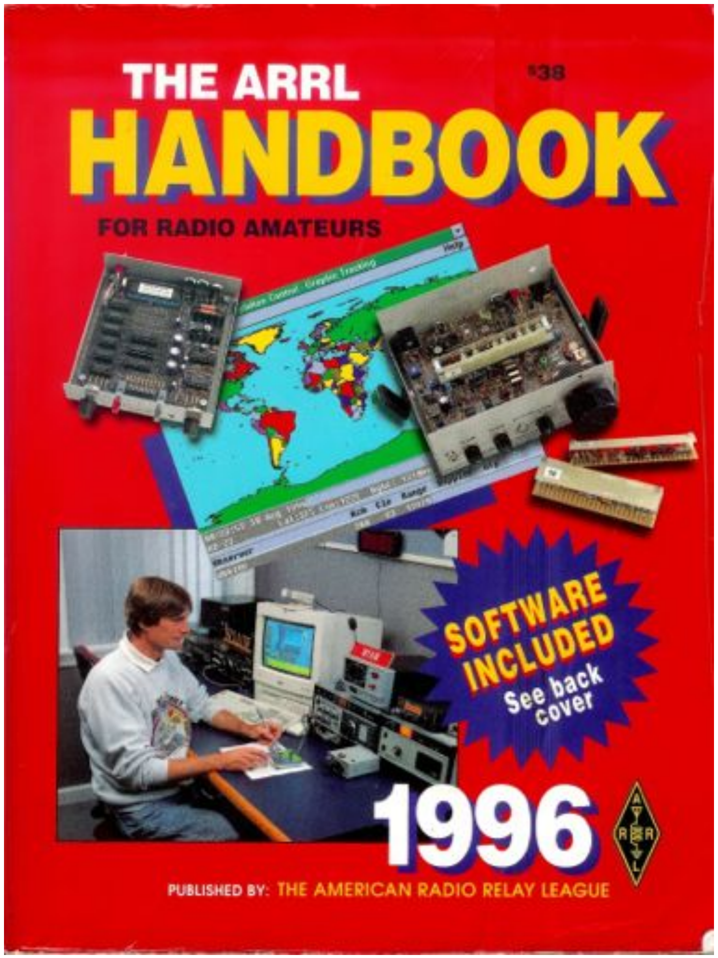
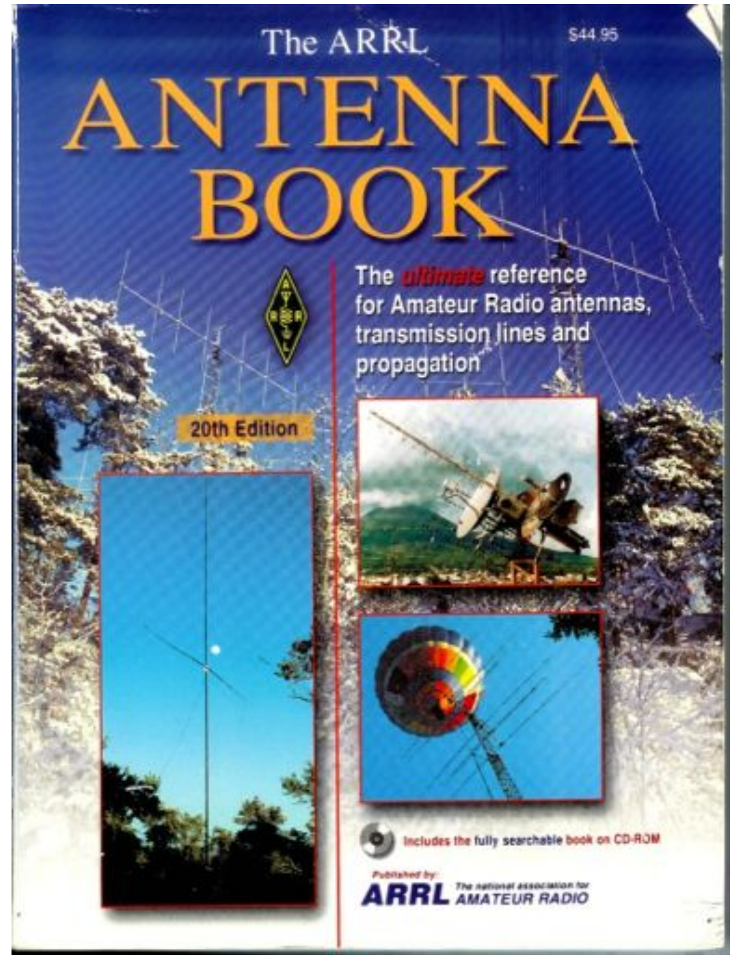
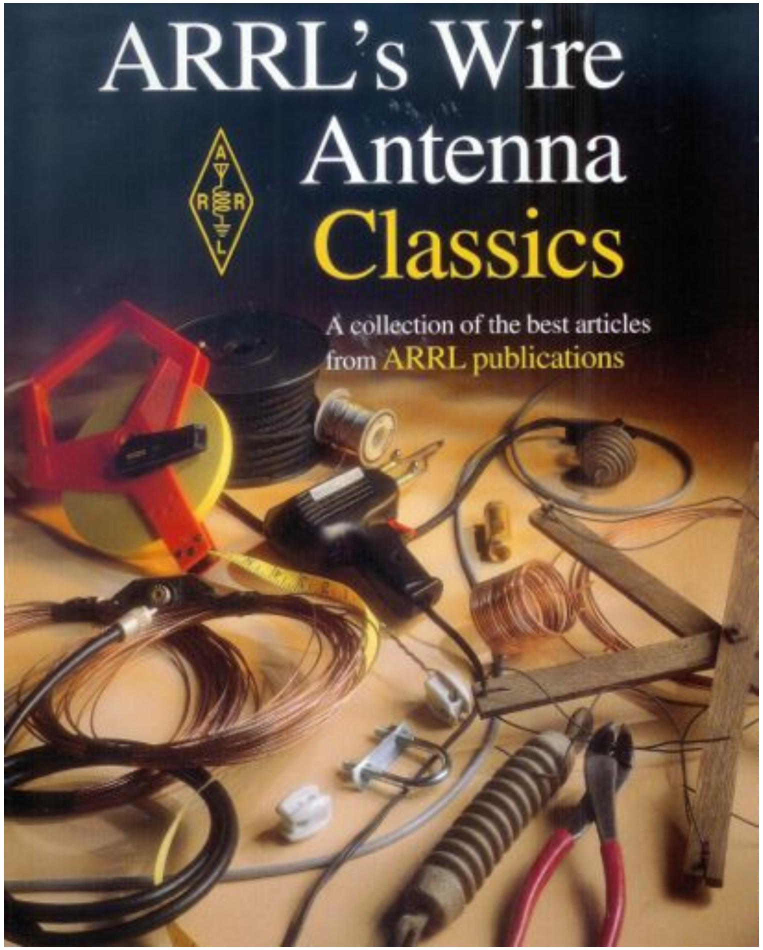
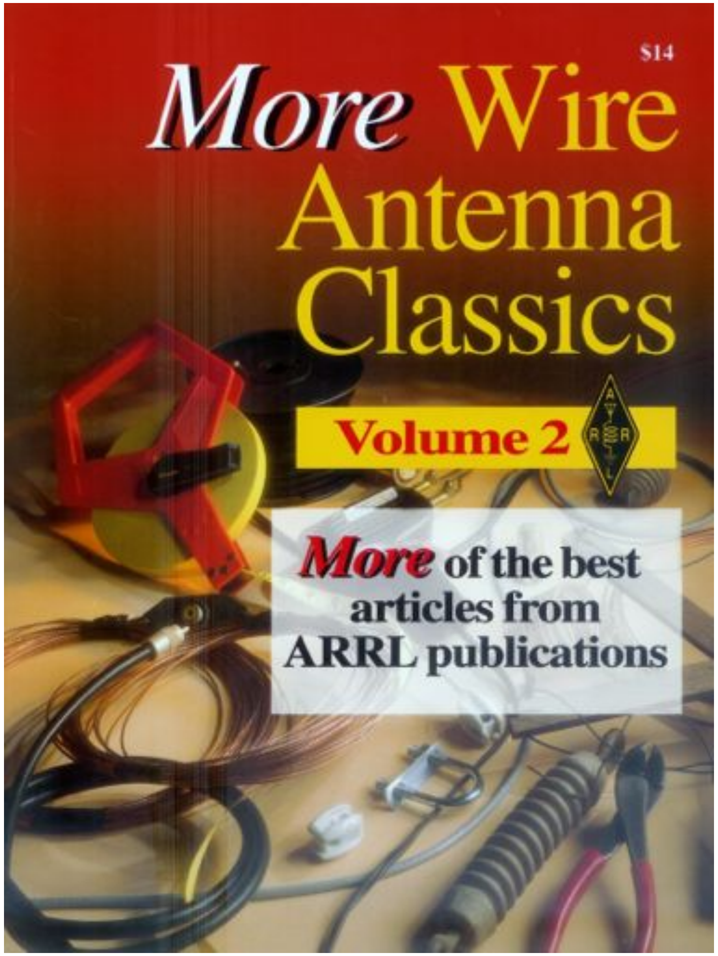
ARRL Essential Publications





ARRL Wire Antenna Publications





HF Wire Antenna

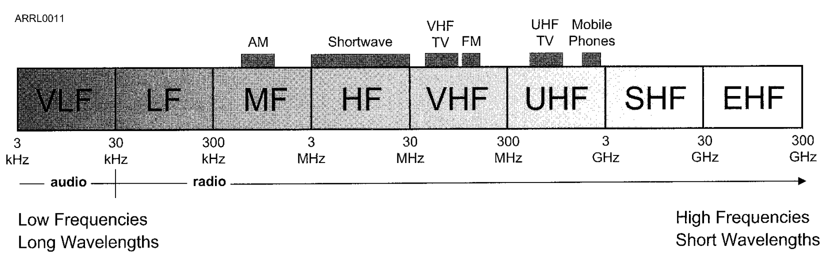
- Polarization
- Impedance
- Long Wire
- Loop
- Windom
- Vertical
- Antenna Tuners

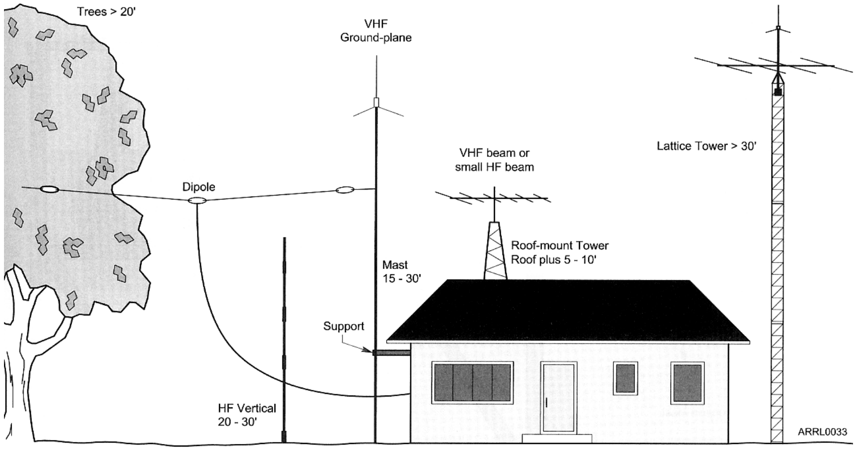
- Dipoles
  - Simple
  - Sloper
  - Inverted “V”
  - Fan
  - Trap
  - Folded
- G5RV
- Zepp
  - End fed
  - Center fed

Simple HF Wire Antenna

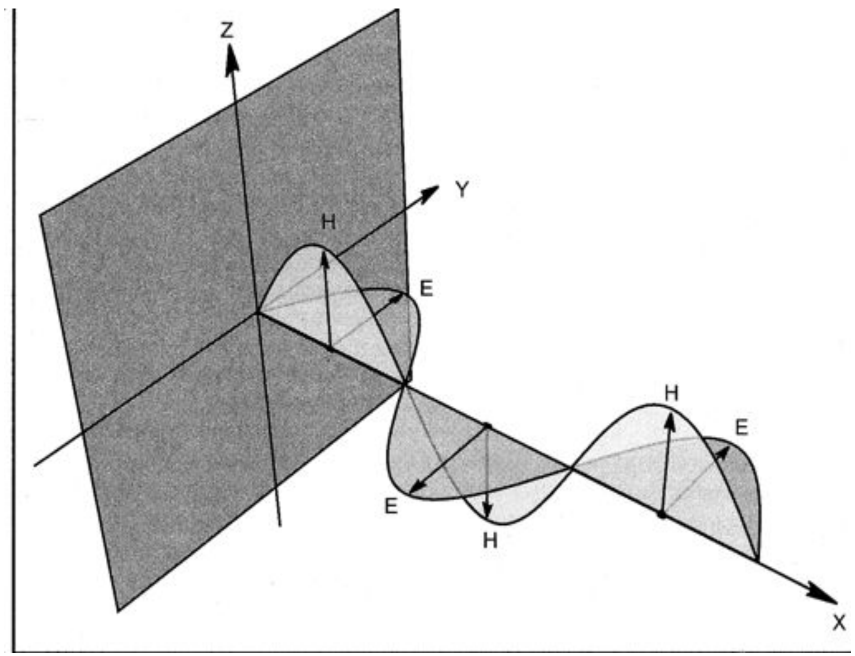
We will explore typical variations of the wire dipole high frequency (HF) antenna

Typical Amateur Radio Transmitting Antenna



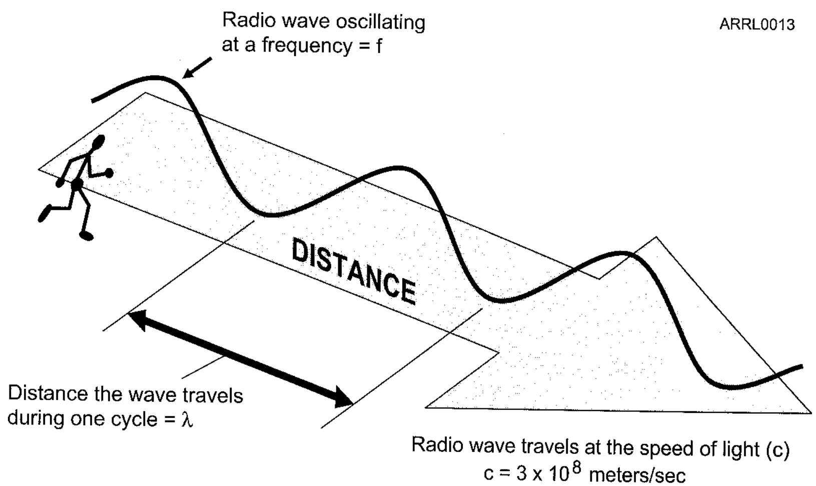


Electromagnetic Wave Polarization



- Electric and magnetic waves are at right angles to each other
- Magnetic wave dissipates within a few wavelengths of antenna
- Electric wave facilitates communications
- Polarization is the orientation of the electric field of the electromagnetic wave
- A horizontally orientated antenna, such as a dipole, emits a horizontally polarized electric wave that is parallel to surface of the earth (like the antenna)
- A vertically orientated antenna, such as a mobile whip, emits a vertically polarized electric wave that is perpendicular to the surface of the earth (like the antenna)

How many meters? (or feet?)



$\lambda = c/f = 300 / f$ in MHz

$$\lambda_{meters} = \frac{299.7925 \times 10^6 \text{ meters/sec}}{\text{f hertz}} = \frac{299.7925}{\text{f MHz}} \qquad \text{(Eq 1)}$$

where λ_{meters} , the Greek letter lambda, is the free-space wavelength in meters.

Expressed in feet, Eq 1 becomes:

$$\lambda_{feet} = \frac{983.5712}{\text{f MHz}} \approx \frac{983.6}{\text{f MHz}} \qquad \text{(Eq 2)}$$

RF Signal Polarization

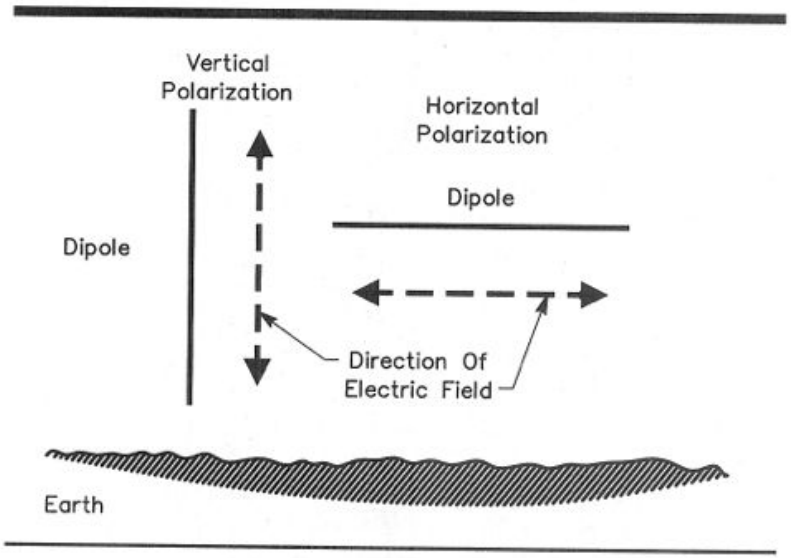


Fig 19—Vertical and horizontal polarization of a dipole above ground. The direction of polarization is the direction of the maximum electric field with respect to the earth.

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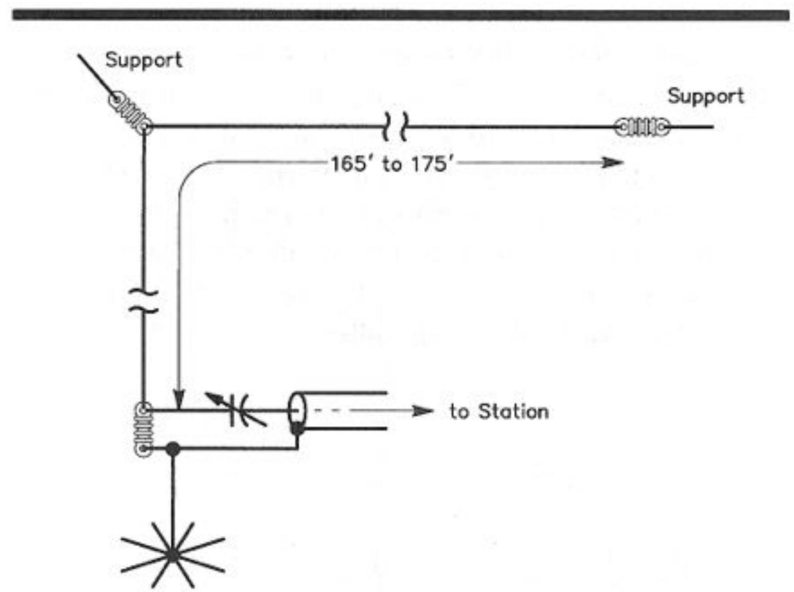

Fig 57—The 1.8-MHz inverted L. Overall wire length is 165 to 175 feet. The variable capacitor has a capacitance range from 100 to 800 pF, at 3 kV or more. Adjust antenna length and variable capacitor for lowest SWR.

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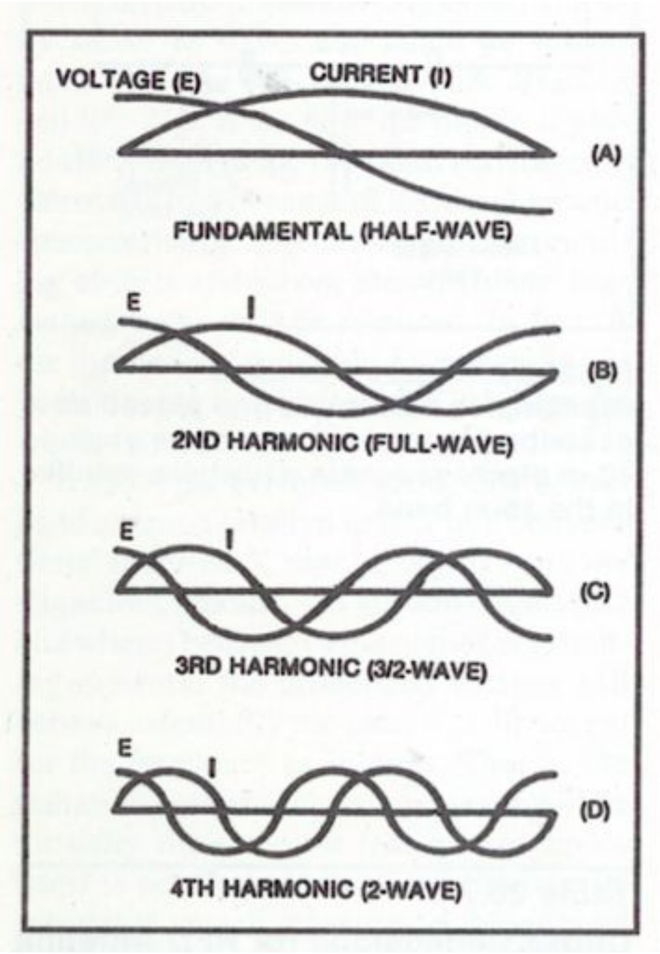
Antenna Impedance Z = e/i



- Voltage and impedance is high when end fed
- Voltage and impedance is low at center on odd harmonics
- Voltage and impedance is high at center on even harmonics

Random Length Long Wire Antenna

- Random length wire – usually one wave length at lowest frequency
- Requires a "tuner" due to wide range of Z
- Unbalanced (single ended) feed
- Typically employs a "pi section" tuner
- RF in the shack
- Ground wire length may figure into antenna length

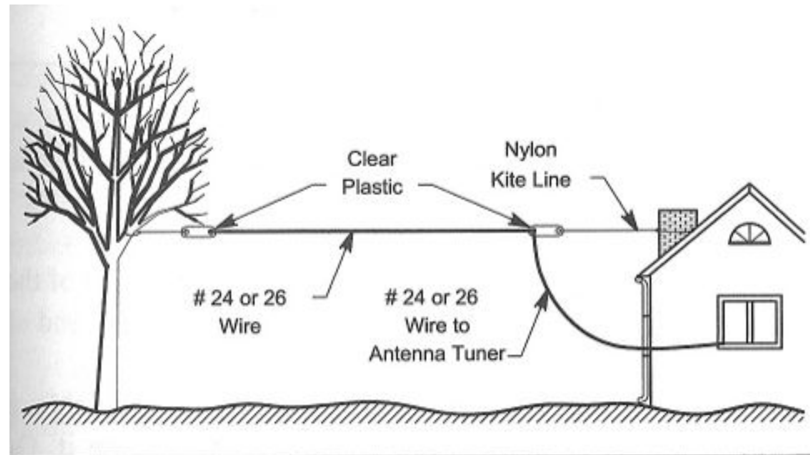


Fig 28—The "invisible" end-fed antenna.

Long Wire or Half Square

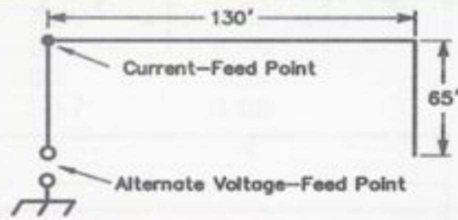


Fig 29—Typical 80-meter half-square, with $\lambda/4$-high vertical legs and a $\lambda/2$-long horizontal leg. The antenna may be fed at the bottom or at a corner. When fed at a corner, the feed point is a low-impedance, current-feed. When fed at the bottom of one of the wires against a small ground counterpoise, the feed point is a high-impedance, voltage-feed.

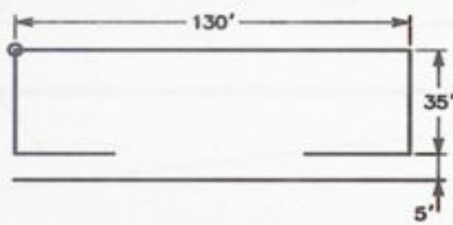
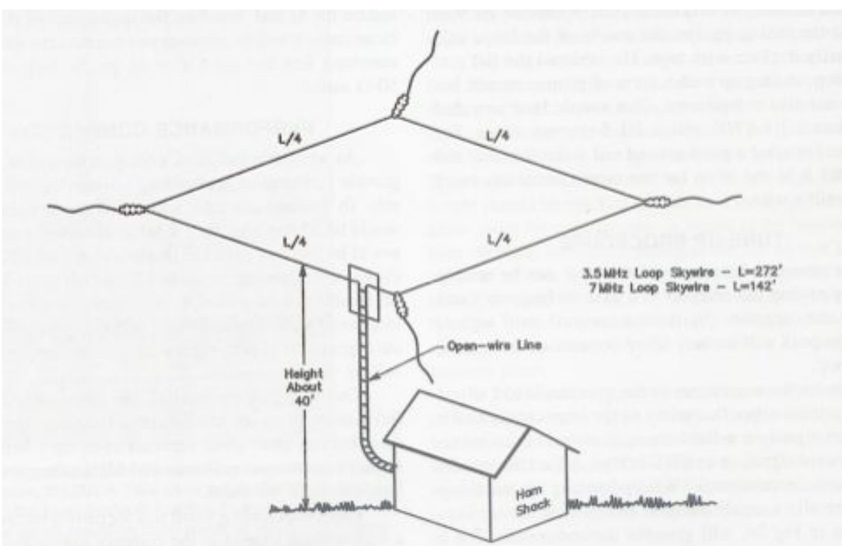
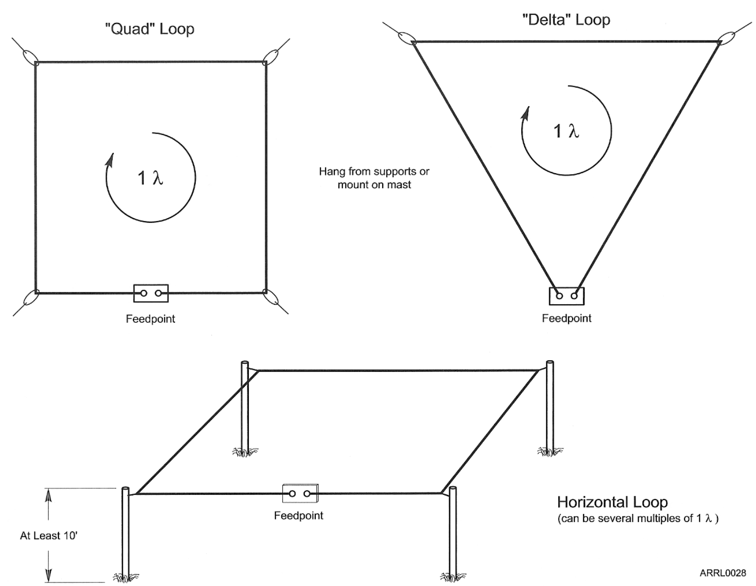


Fig 30—An 80-meter half-square configured for 40-foot high supports. The ends have been bent inward to reresonate the antenna. The performance is compromised surprisingly little.

Horizontal Loop

- Need not be a square
- Works well as multi-band antenna
- Open wire or coax feed line
- Usually cut to one wavelength at lowest frequency
- Balanced load
- May require balun
- Will require an antenna tuner
- Polarization same as plane of loop





Windom Multi-band Wire Antenna

- Requires a "tuner" due to wide range of Z
- Unbalanced (single ended) load and feed
- Typically employs a "pi section, T section or L section" tuner
- RF in the shack similar to long wire

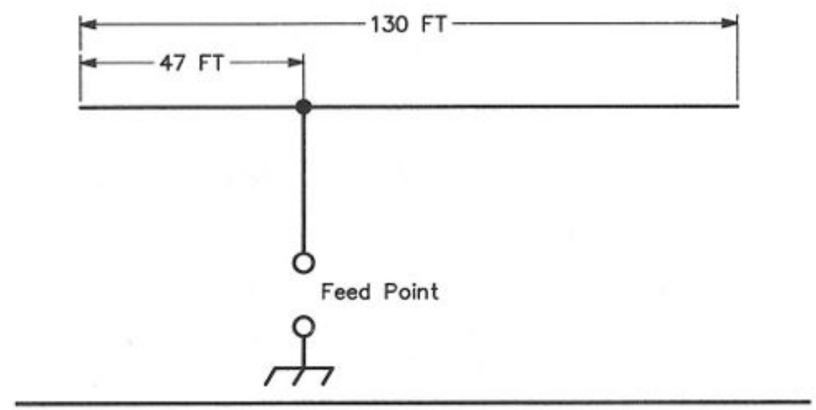
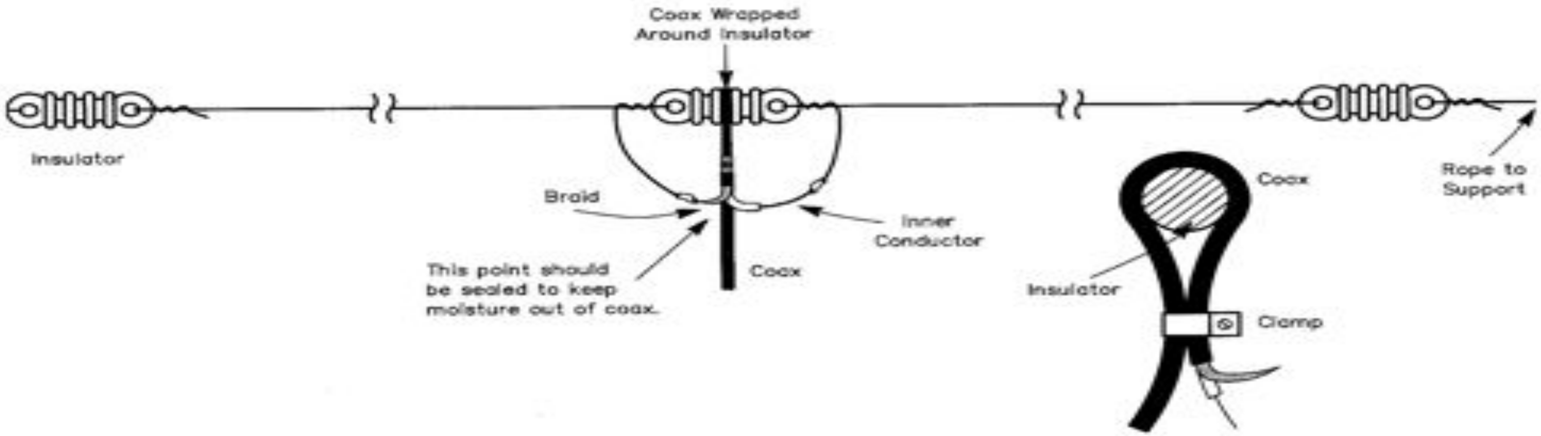


Fig 12—The Windom antenna, cut for a fundamental frequency of 3.75 MHz. The single-wire feeder, connected 14% off center, is brought into the station and the system is fed against ground. The antenna is also effective on its harmonics.

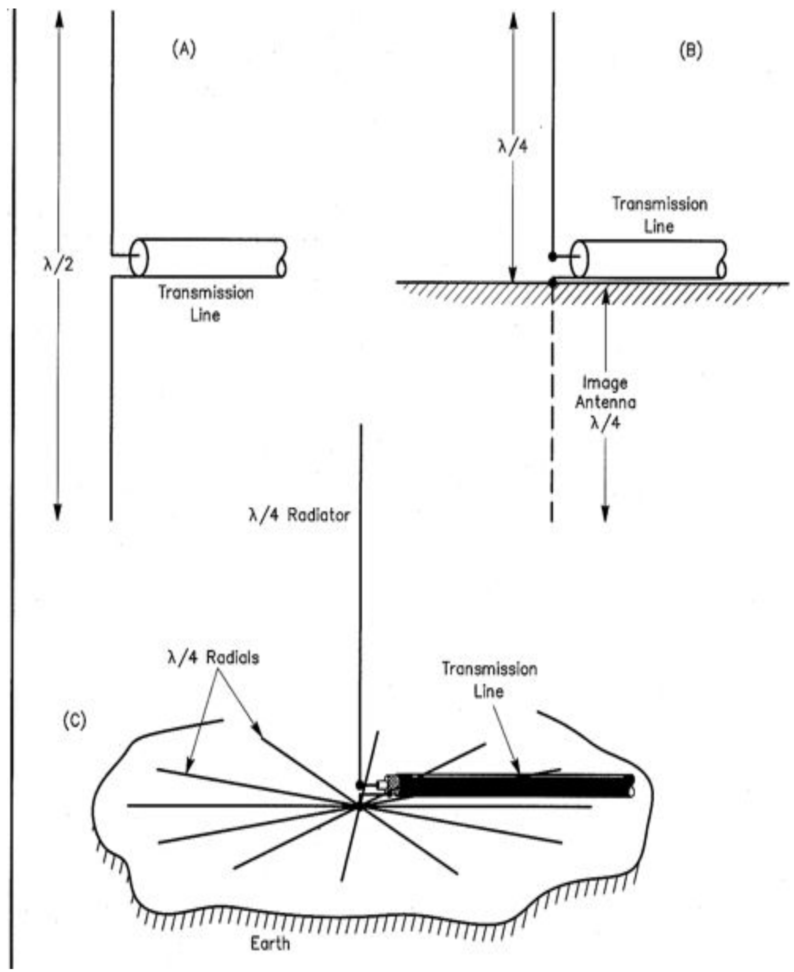
Multiband Antennas 7-7

Half-Wavelength Dipole



- Most common HF antenna in amateur radio
- Resonate antenna on the frequency for which it is designed
- L_{feet} = 468/f in MHz

Vertical Wire Antenna



- Actually a vertically orientated resonate 1/2 wave dipole with the earth being the "return" half
- Due to poor ground conductivity a set of 1/4 wavelength long radials may be required
- Emits a low angle vertically polarized electric field
- Used where space is limited and for DX which requires a low angle of radiated signal for longest signal hop
- Perfect ground conditions result in a 36 ohm radiation resistance for a 1/4 wave vertical but in practice it will be 30 to 100 ohms

Multiband Wire Verticals up a Tree

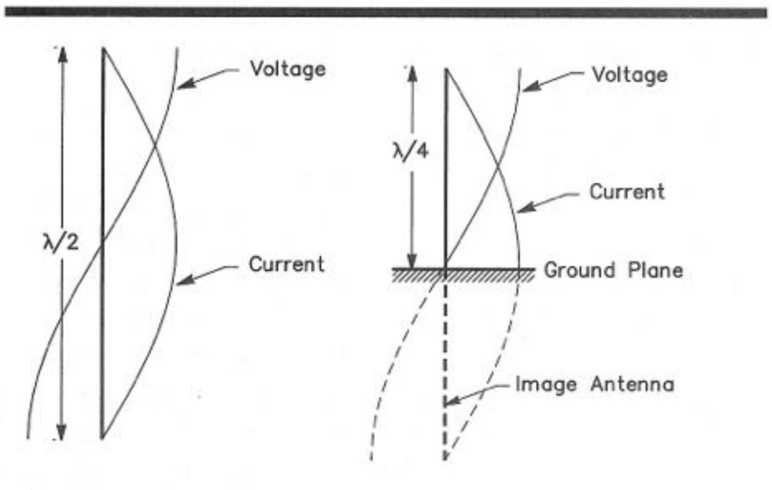


Fig 21—The $\lambda/2$ dipole antenna and its $\lambda/4$ ground-plane counterpart. The "missing" quarter wavelength is supplied as an image in "perfect" (that is, high-conductivity) ground.

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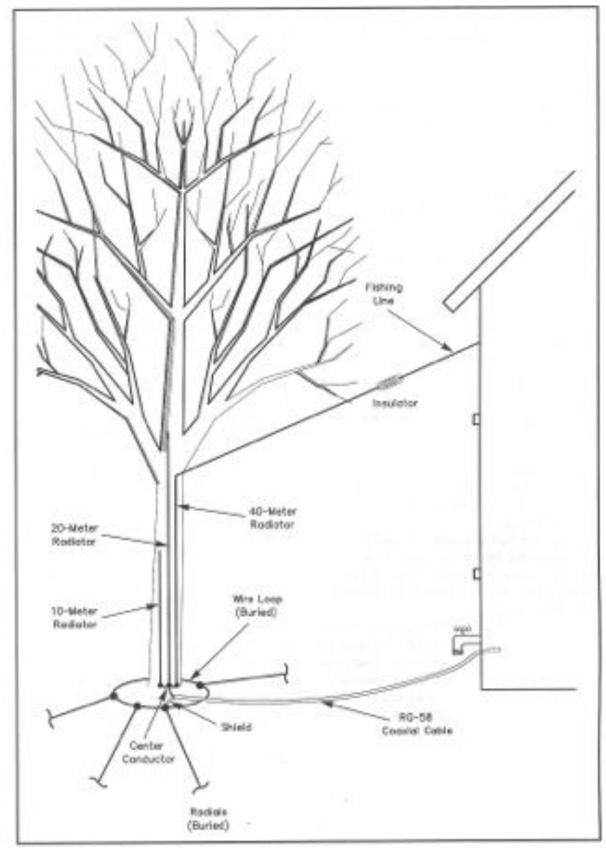

Fig 1—Run the three antenna wires along the trunk and then, if necessary, bend them along the branches. My 40-meter wire is so long that it leaves the tree altogether and attaches to my window frame. Use at least six radials for your ground system, more if you have the space and the patience to place them beneath the soil.

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Inverted "L" Antenna

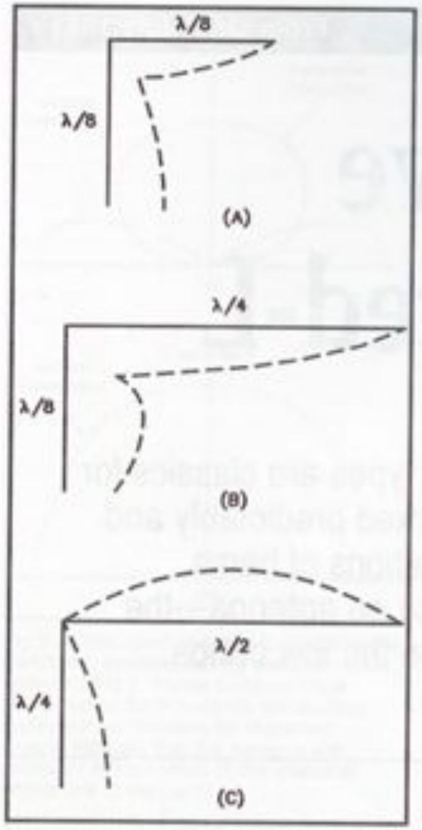


Fig 1—At A, the basic inverted L commonly used on the lower-frequency ham bands. The dotted line represents current distribution. The $^3/_8$-wavelength inverted L shown at B features a more favorable current distribution. At twice the fundamental (C), the antenna at B acts as a $^3/_4$-λ wire. Note the two current maxima. The antenna behaves like a quarter-wave vertical end-feeding a half-wave dipole.

the pattern more closely resembles the pattern of a dipole at the same height. At twice the antenna's lower operating frequency, this antenna works best for short- and medium-distance contacts, but I've worked my share of DX with it, too.

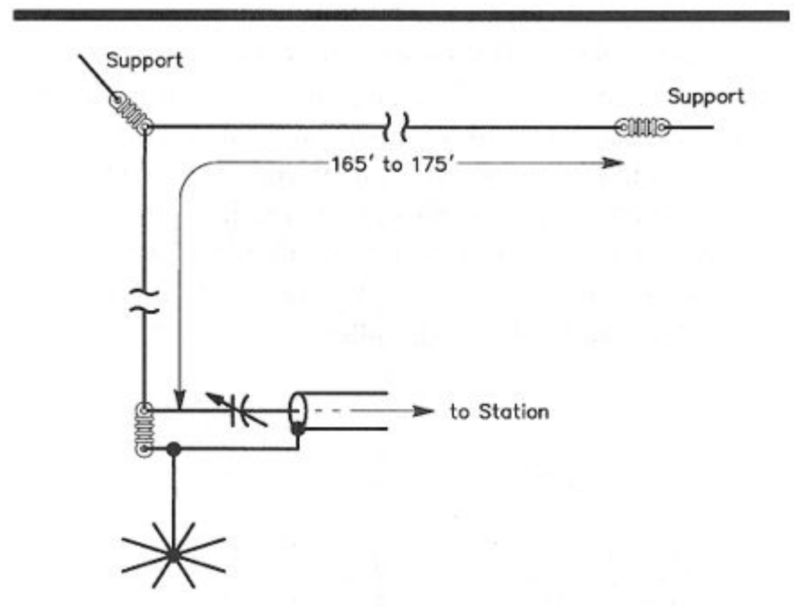
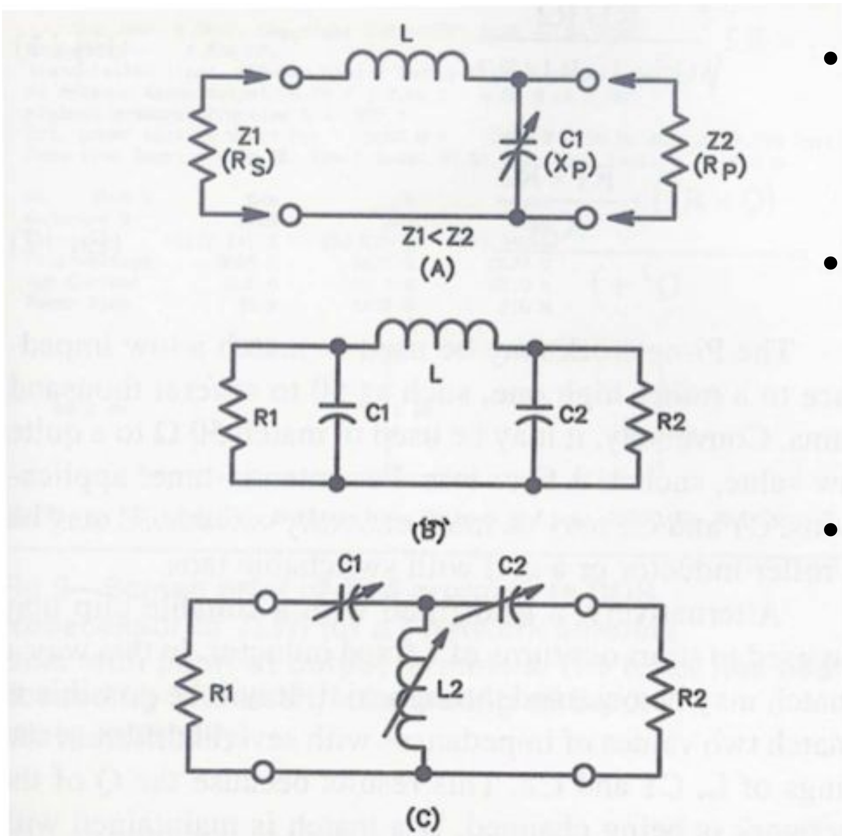


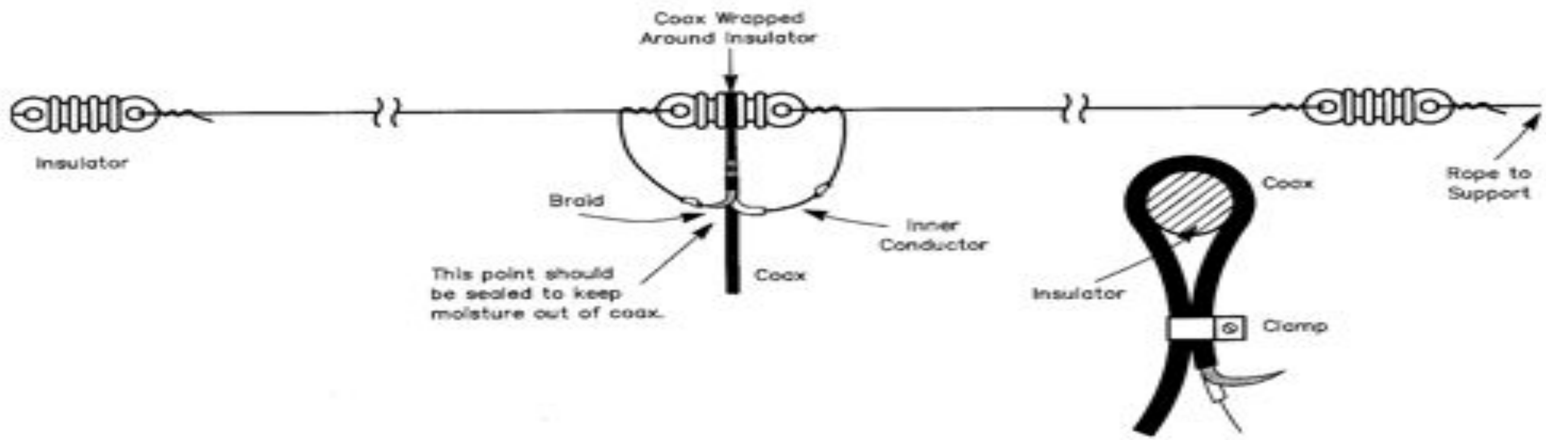
Fig 57—The 1.8-MHz inverted L. Overall wire length is 165 to 175 feet. The variable capacitor has a capacitance range from 100 to 800 pF, at 3 kV or more. Adjust antenna length and variable capacitor for lowest SWR.

Unbalanced (single ended) "L", "Pi" and "T" Section Tuners



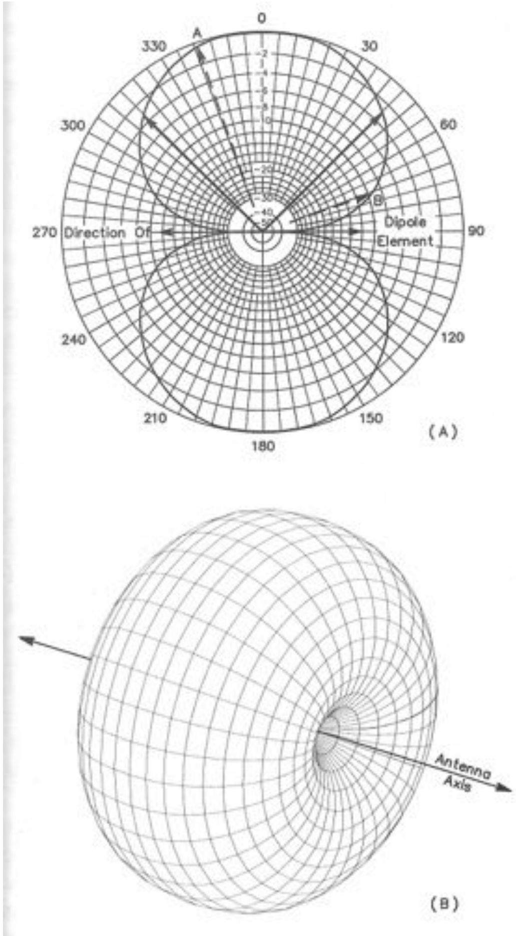
- Unbalanced transmitter output to unbalanced feed line (coax) and antenna
- Transforms the antenna impedance at the feed line output to 50 ohms to match the transmitter 50 ohm output impedance
- The capacitors and inductor setting must be varied as the operating frequency and resulting antenna impedance vary

Half-Wavelength Dipole



- Resonate antenna on the frequency for which it is designed
- L_{feet} = 468/f in MHz
- Radiation resistance of 72 ohms when elevated at 0.25 wavelength
- Balanced Load
- Horizontally polarized
- Most common antenna for HF
- Invented by Heinrich Hertz about 1886

Center fed dipole is a simple, effective antenna



(A)

(B)

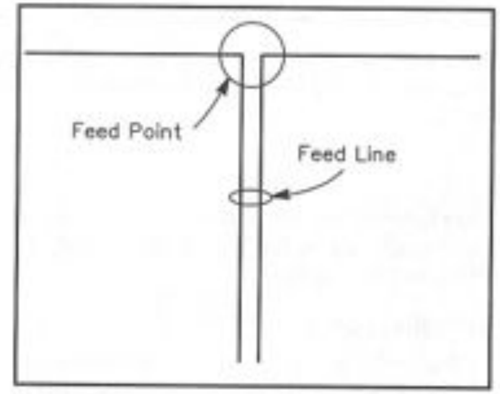


Fig 1—One of the simplest antennas used by hams, the dipole is also one of the most effective, considering the relatively small space it requires. In its simplest form, a dipole is a wire fed at its center.

Table 1

Approximate Lengths of Half-Wave Dipoles for the MF/HF Ham Bands*

Frequency	*Length*
28.4 MHz	16 ft, 6 in.
24.9 MHz	18 ft, 10 in.
21.1 MHz	22 ft, 2 in.
18.1 MHz	25 ft, 10 in.
14.1 MHz	33 ft, 2 in.
10.1 MHz	46 ft, 4 in.
7.1 MHz	65 ft, 11 in.
3.6 MHz	130 ft
1.8 MHz	260 ft

*General equation for half-wave dipole length: $\ell = 468 \div f$, where ℓ is length in feet and f is frequency in megahertz. This equation yields good starting points; you may have to lengthen or trim your antenna to achieve resonance. See the sidebar entitled "Dipole Construction and Adjustment."

Radiation Pattern Varies With Frequency of Operation & Height

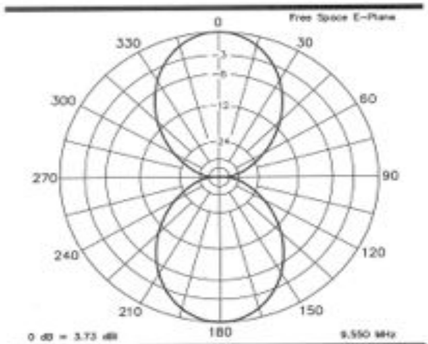


Fig 14—Free-space E-Plane radiation pattern for a 100-foot dipole at its full-wave resonant frequency of 9.55 MHz. The gain has increased to 3.73 dBi, because the main lobes have been focused and sharpened compared to Fig 12.

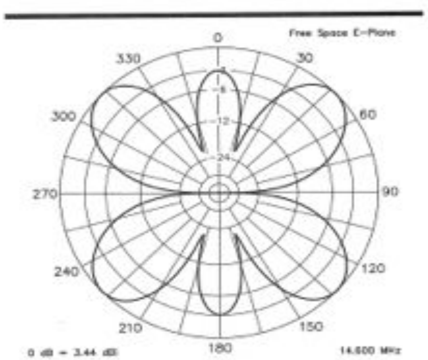


Fig 15—Free-space E-Plane radiation pattern for a 100-foot dipole at its 3/2λ resonant frequency of 14.60 MHz. The pattern has broken up into six lobes, and thus the peak gain has dropped to 3.44 dBi.

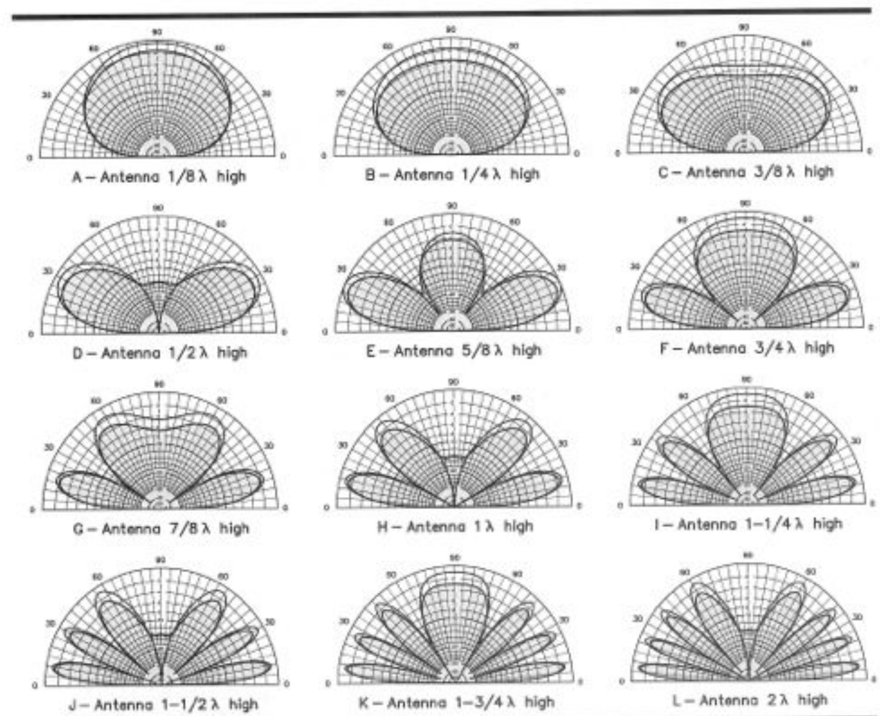


Fig 25—Reflection factors for horizontal dipole antennas at various heights above flat ground. The solid-line curves are the perfect-earth patterns (broadside to the antenna wire); the shaded curves represent the effects of average earth (k = 13, G = 0.005 S/m) at 14 MHz. Add 7 dB to values shown for absolute gain in dBd referenced to dipole in free space, or 9.15 dB for gain in dBi. For example, peak gain over perfect earth at 5/8 λ height is 7 dBd (or 9.15 dBi) at 25° elevation.

Impedance Varies with Height

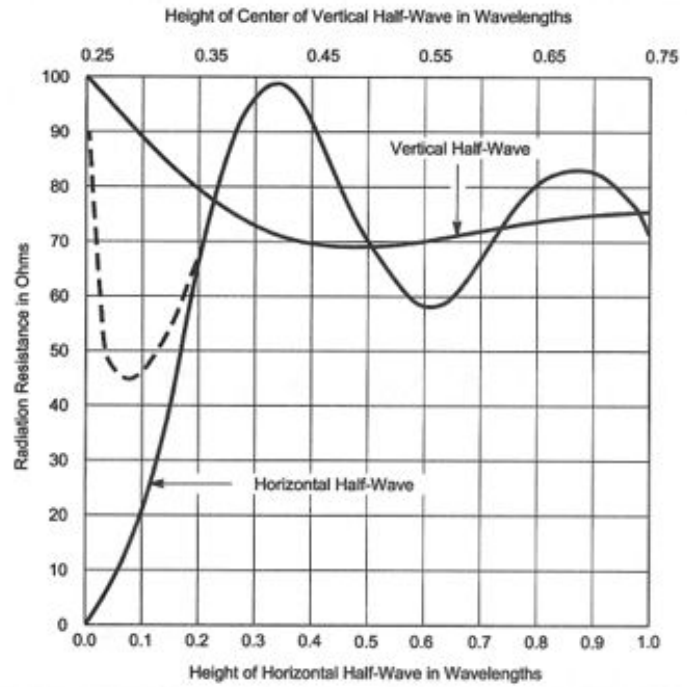


Fig 1—Variation in radiation resistance of vertical and horizontal half-wave antennas at various heights above flat ground. Solid lines are for perfectly conducting ground; the broken line is the radiation resistance of horizontal half-wave antennas at low height over real ground.

Many Other Types of Dipoles

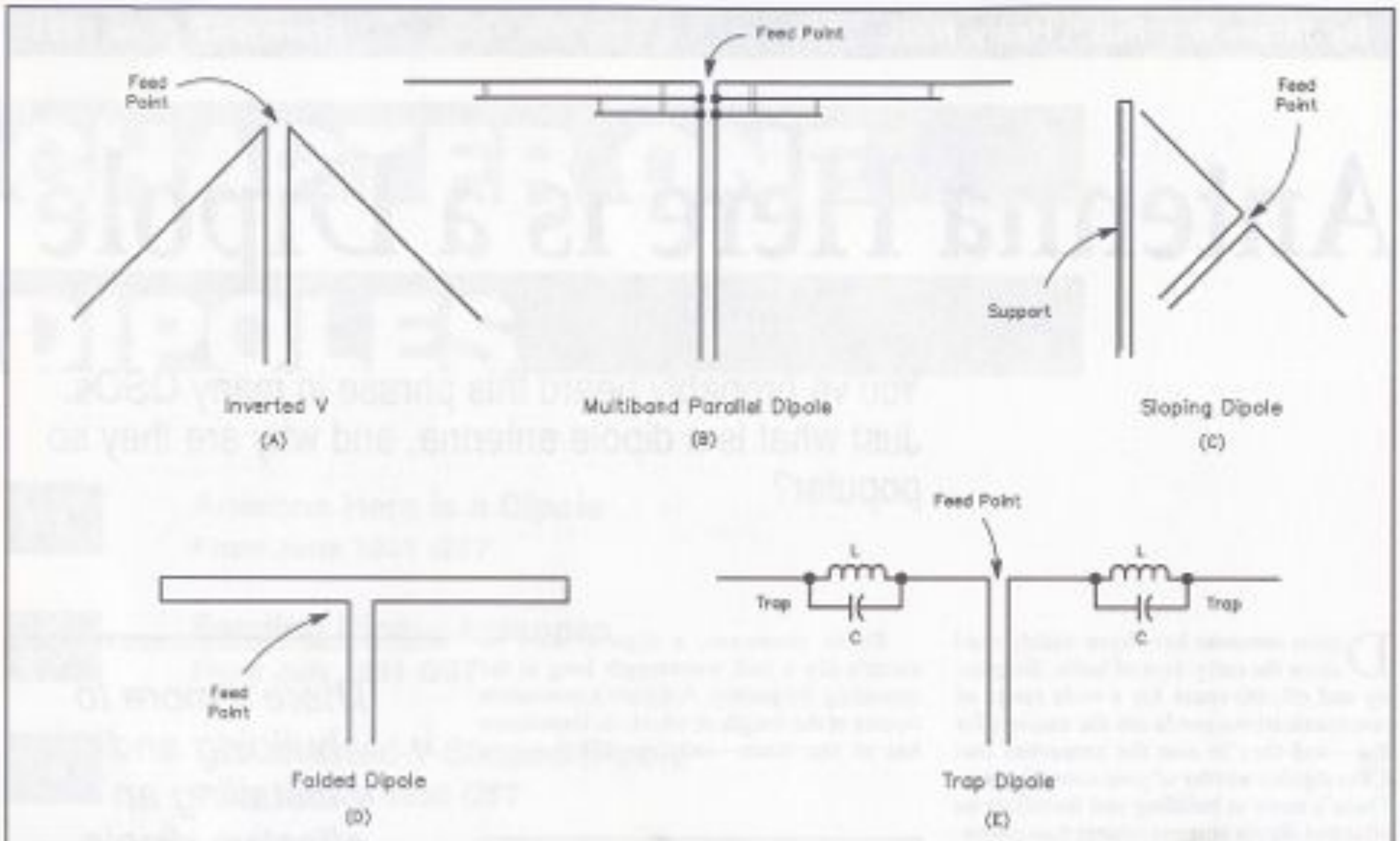


Fig 2—Variations on the dipole are numerous: at A, an inverted V; at B, a multiband parallel dipole; at C, a sloping dipole (sloper); at D, a folded dipole, and at E, a trap dipole. Dipoles of the multiband parallel, trap and folded varieties can be installed in sloping or inverted-V configurations.

Inverted “V” Dipole

Relative to Horizontal Dipole

1. **Single support**
2. **Slightly less gain**
3. **Slightly less directionality**
4. **Slightly longer for freq.**
5. **Slightly lower feed point Z**
6. **SWR varies with apex angle**

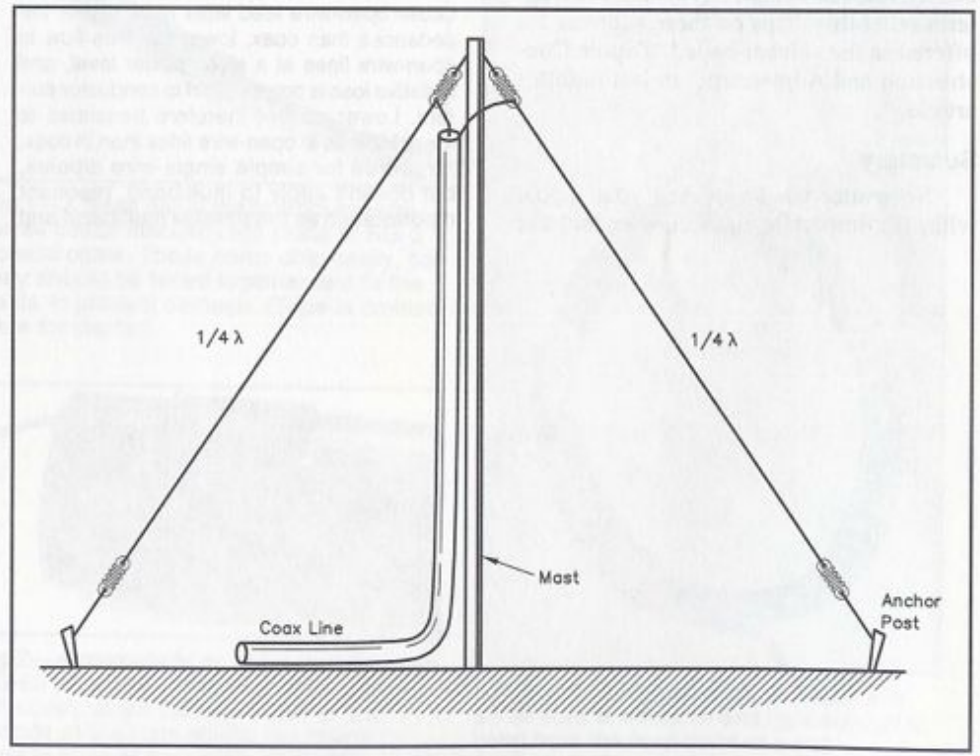
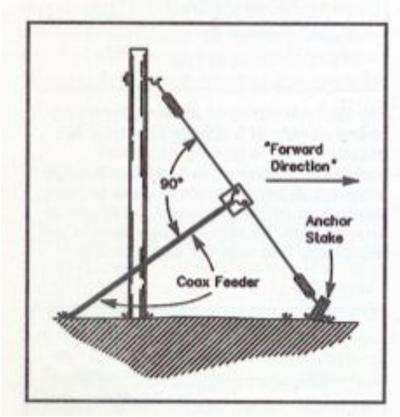
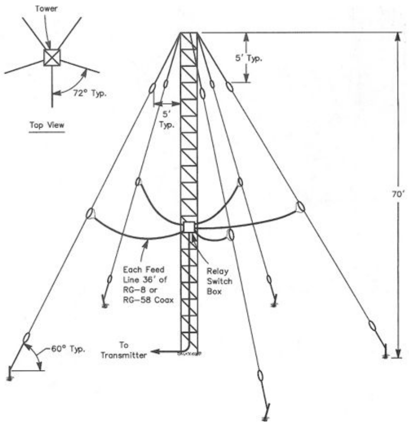


Fig 1—The inverted-vee dipole. The length should be adjusted as described in the text.

Half Wavelength Sloper Dipoles





- Favors signals off the front of antenna
- No gain over dipole
- Metal support acts as a parasitic element and impacts gain and pattern

Off Center Fed Dipole

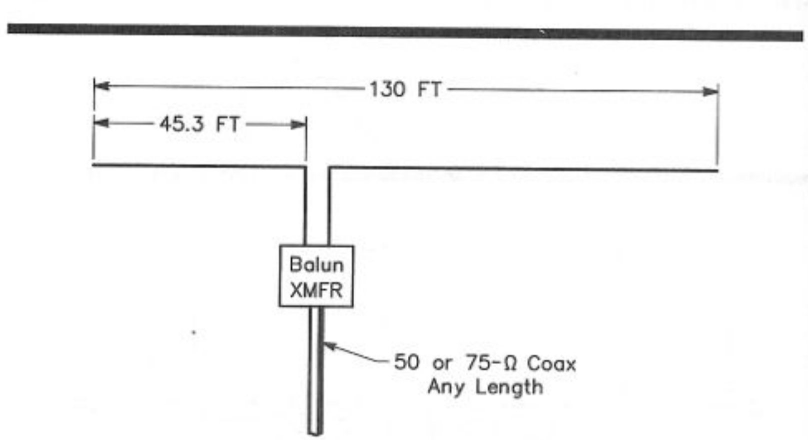
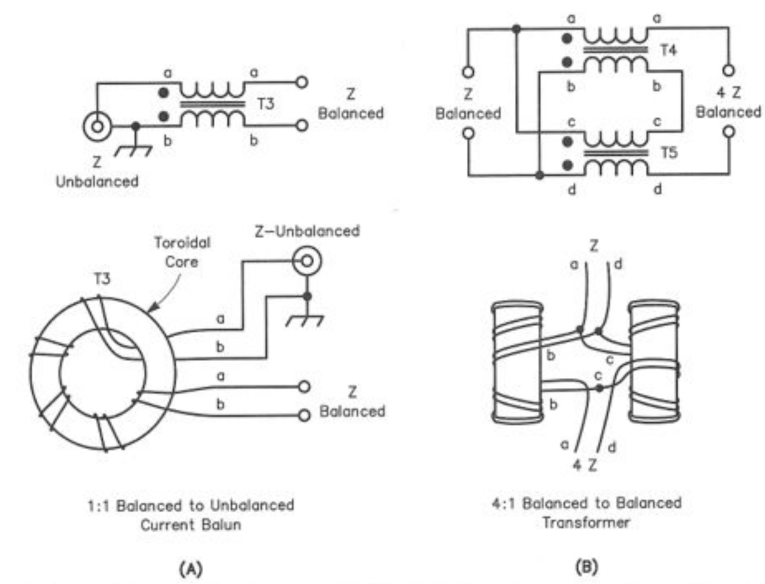


Fig 18—The off-center-fed (OCF) dipole for 3.5, 7 and 14 MHz. A 1:4 or 1:6 step-up current balun is used at the feed point.



Multiband Dipoles

Fan Dipole for several bands

- **Each dipole is a resonate circuit tuned to the band of interest.**
- **The non-resonate dipoles reject unrelated power**

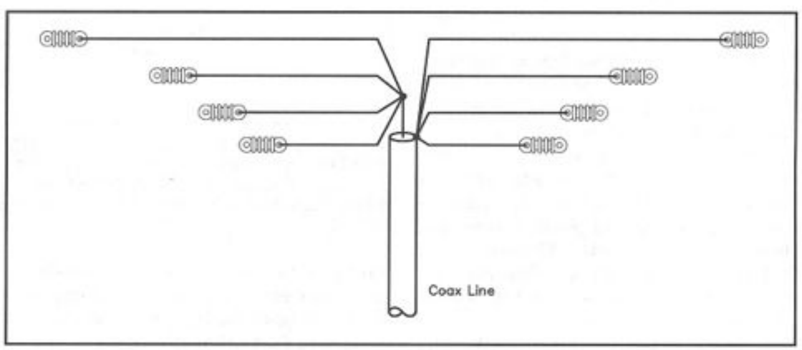
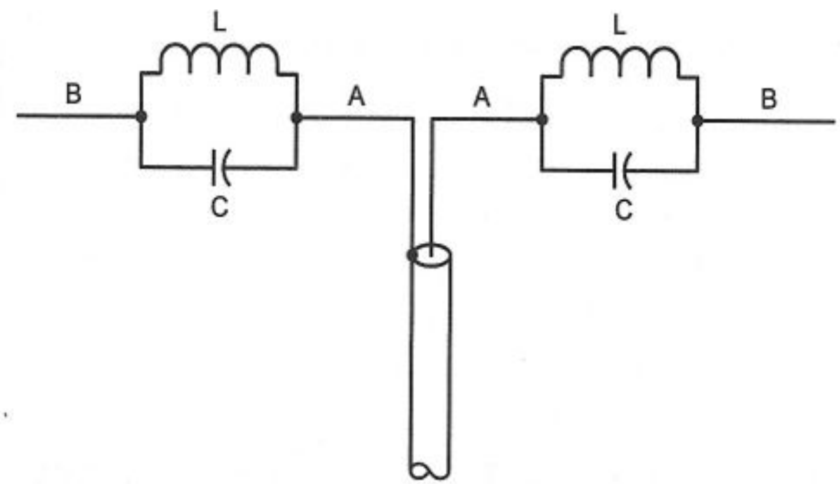


Fig. 1—Sketch showing the arrangement of parallel half-wave antennas in the coax-fed multiband antenna system.

Trap Dipole for 40/80 meters

The LC circuit presents a high impedance at 40 meters and low impedance at 80 meters



Using Current Chokes

Transmitter current travels on center conductor and inside of the shield of co-axial cable feed line – shield current feeds antenna leg and outside of shield – RF current on outside of shield radiates like a vertical antenna and also travels back into the shack – current choke balun at feed point "chokes" the RF current on outside of co-axial feed line

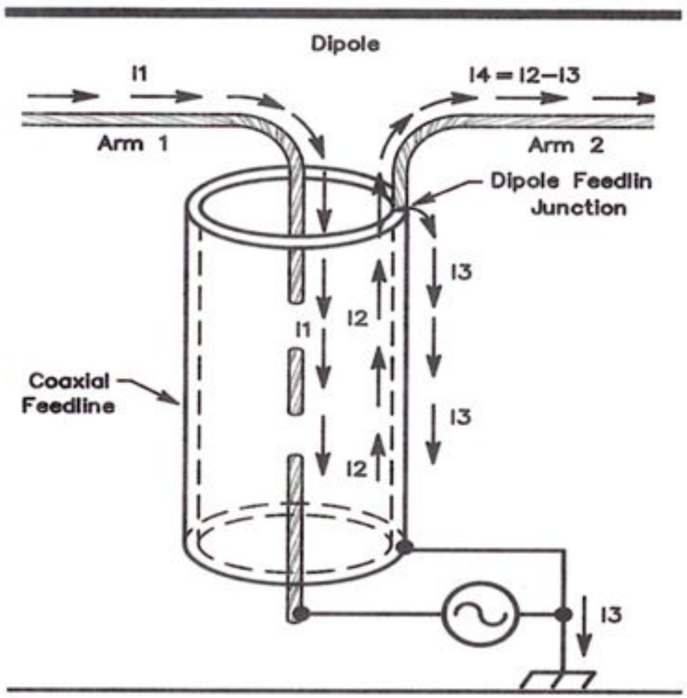


Fig 24—Drawing showing various current paths at feed point of a balanced dipole fed with unbalanced coaxial cable. The diameter of the coax is exaggerated to show currents clearly.

Coupling the Line to the Antenna 26-17

Fig 1—A bead balun made from several ferrite beads stacked on a piece of RG-8 coaxial cable. These cores chip easily, so they should be taped together and to the cable to prevent damage. (Tape is omitted here for clarity.)

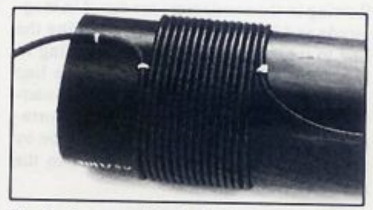


Fig 2—A coaxial-choke balun, wound from RG-58 on a piece of ABS plumbing pipe, effectively stops the flow of RF on the outside of the coax shield, but doesn't impede current flow inside the cable.

Fig 3—A coaxial-cable choke balun with an air core is effective and light enough to hang from the feed point of a well-supported dipole antenna.

Using Z Matching and Current Baluns

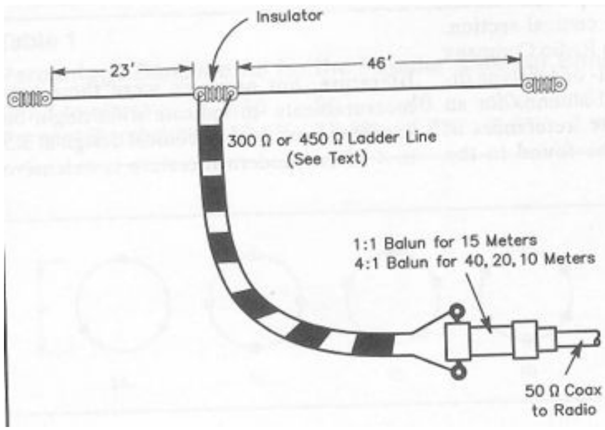


Fig 1—This off-center fed dipole offers four-band performance without an antenna tuner. Just cut the wires and the ladder line to the proper lengths. You'll need to swap baluns when you want to operate on 15 meters.

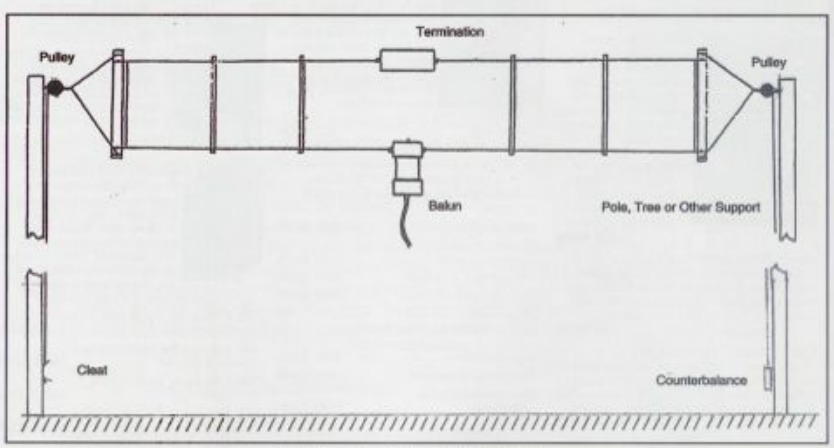


Fig. 1– Broadband terminated folded dipole.

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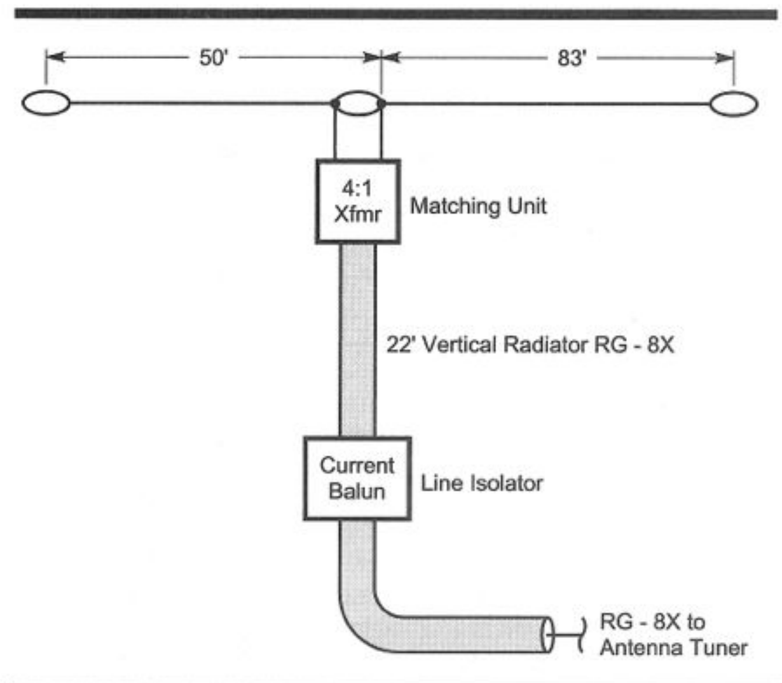
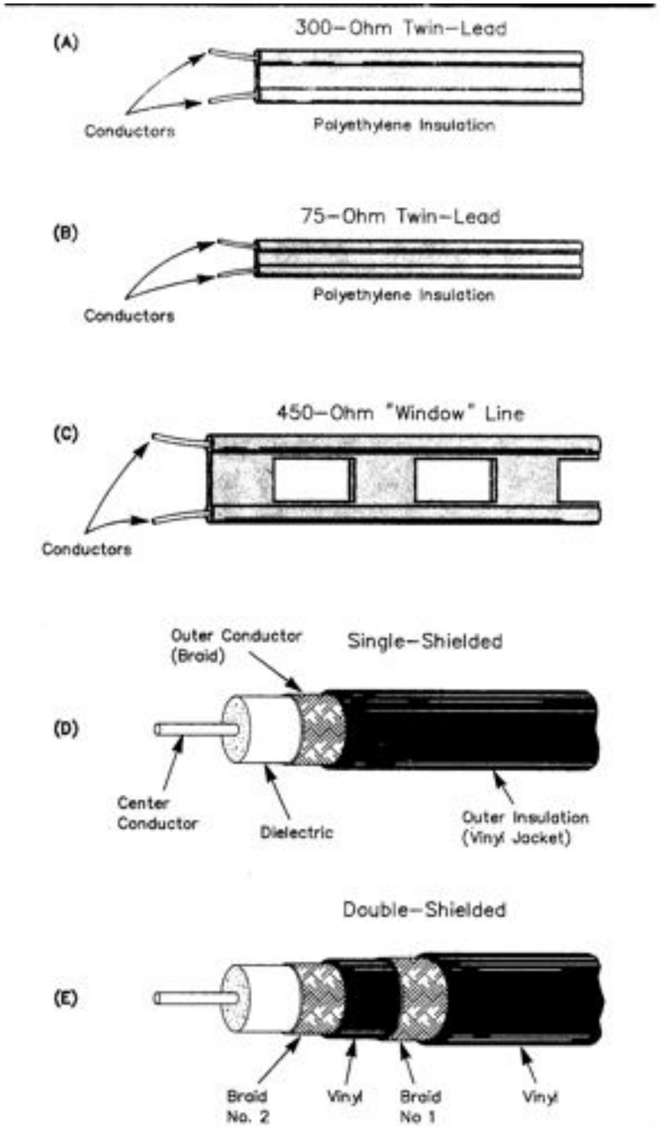


Fig 13—Layout for flattop "Carolina Windom" antenna.

7-8 Chapter 7



Feed lines

- Conducts transmitted power from transmitter to antenna
- Parallel conductor and coaxial cable
- Air insulated conductors have less loss per foot
- As signal frequency increases the signal loss per foot increases

Open Wire (Ladder Line) Feeders

1. Ladder line provides a balanced feed to a balanced load (antenna)
2. Net zero feed line radiation
3. Allows multiband operation
4. Tolerates high SWR and voltage
5. Very low transmission line loss
6. Requires a "balanced to unbalanced" tuner

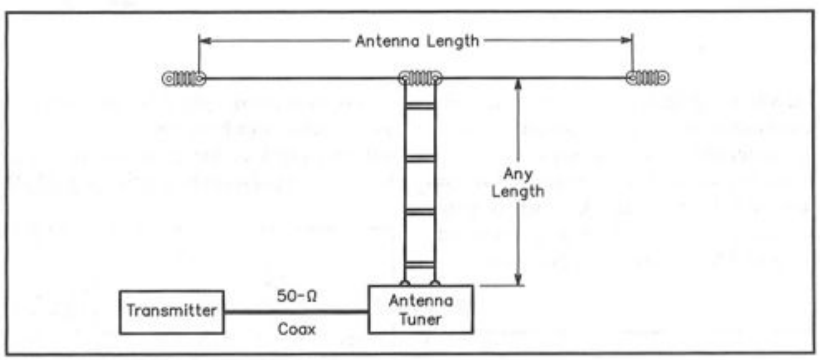
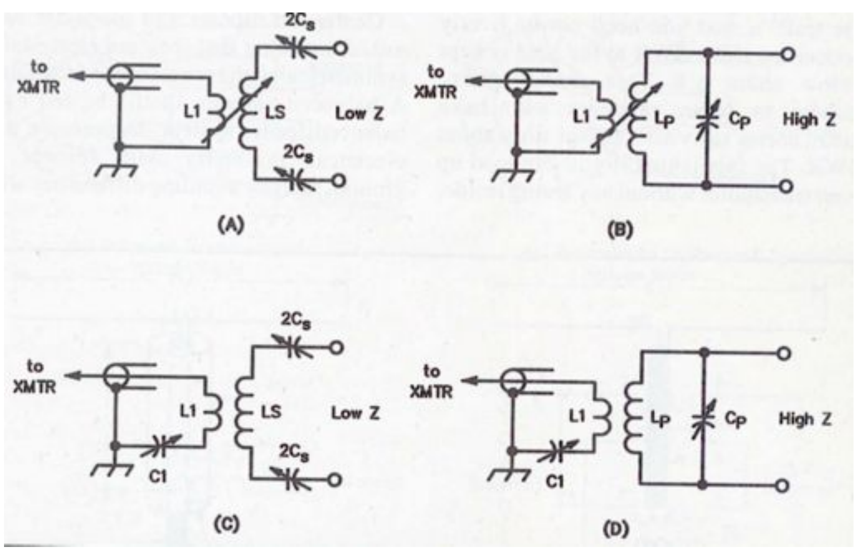


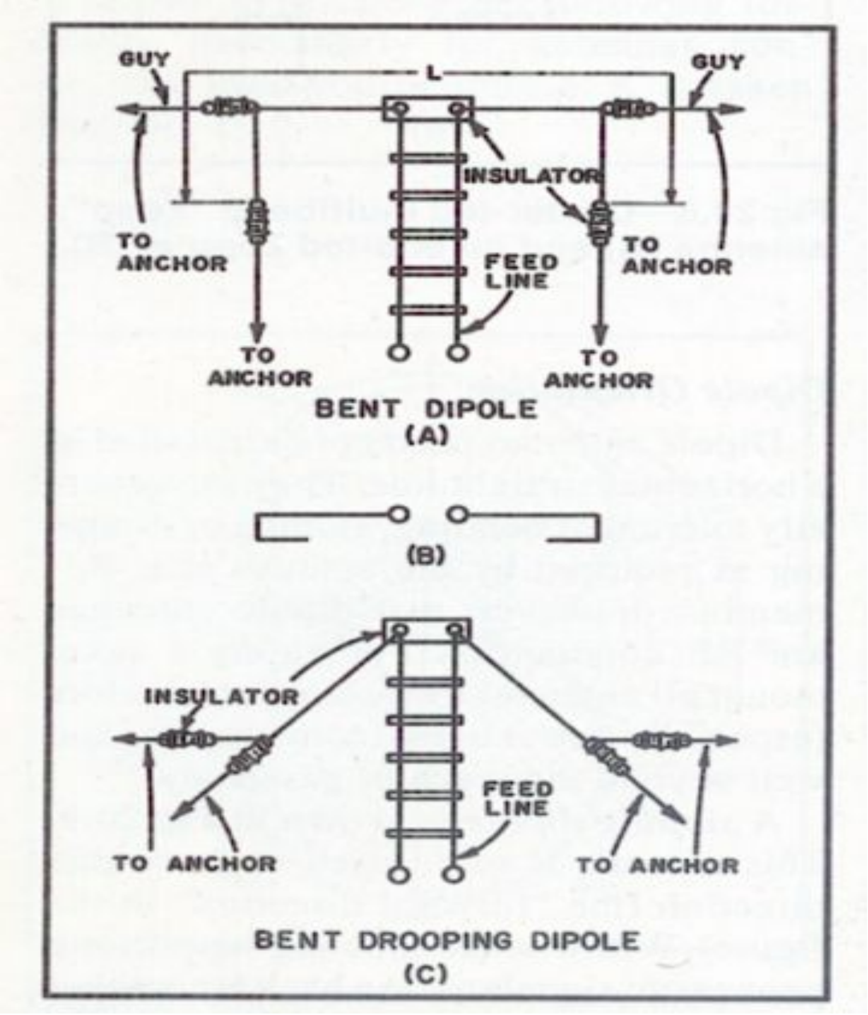
Fig A—A center-fed antenna system for multiband use.

Unbalanced to Balanced Antenna Tuner

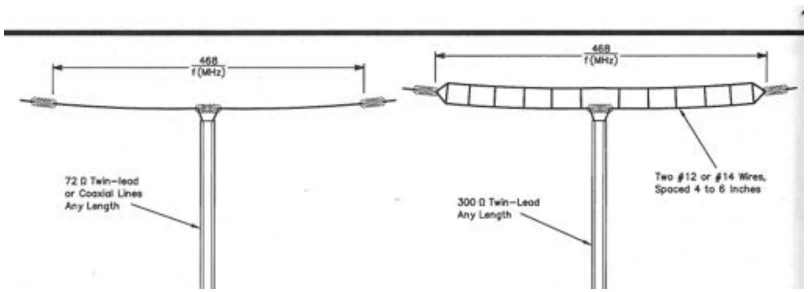


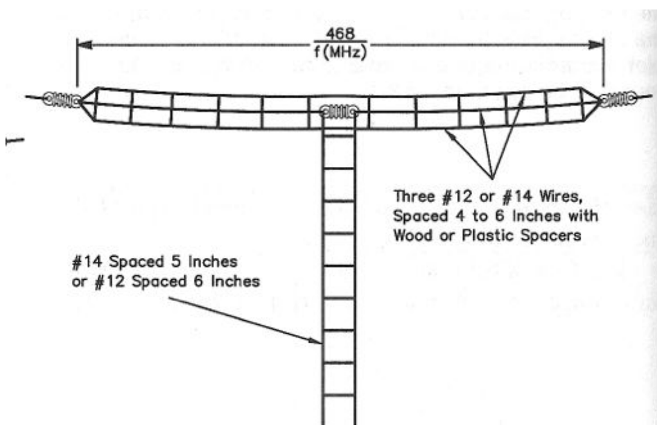
Short Resonate Dipoles

1. Entire length of dipole does not have to be co-linear
2. Bent ends may change resonate frequency slightly
3. Bent ends will change radiation pattern
4. Use of open wire feeder and tuner may allow multi-band operation



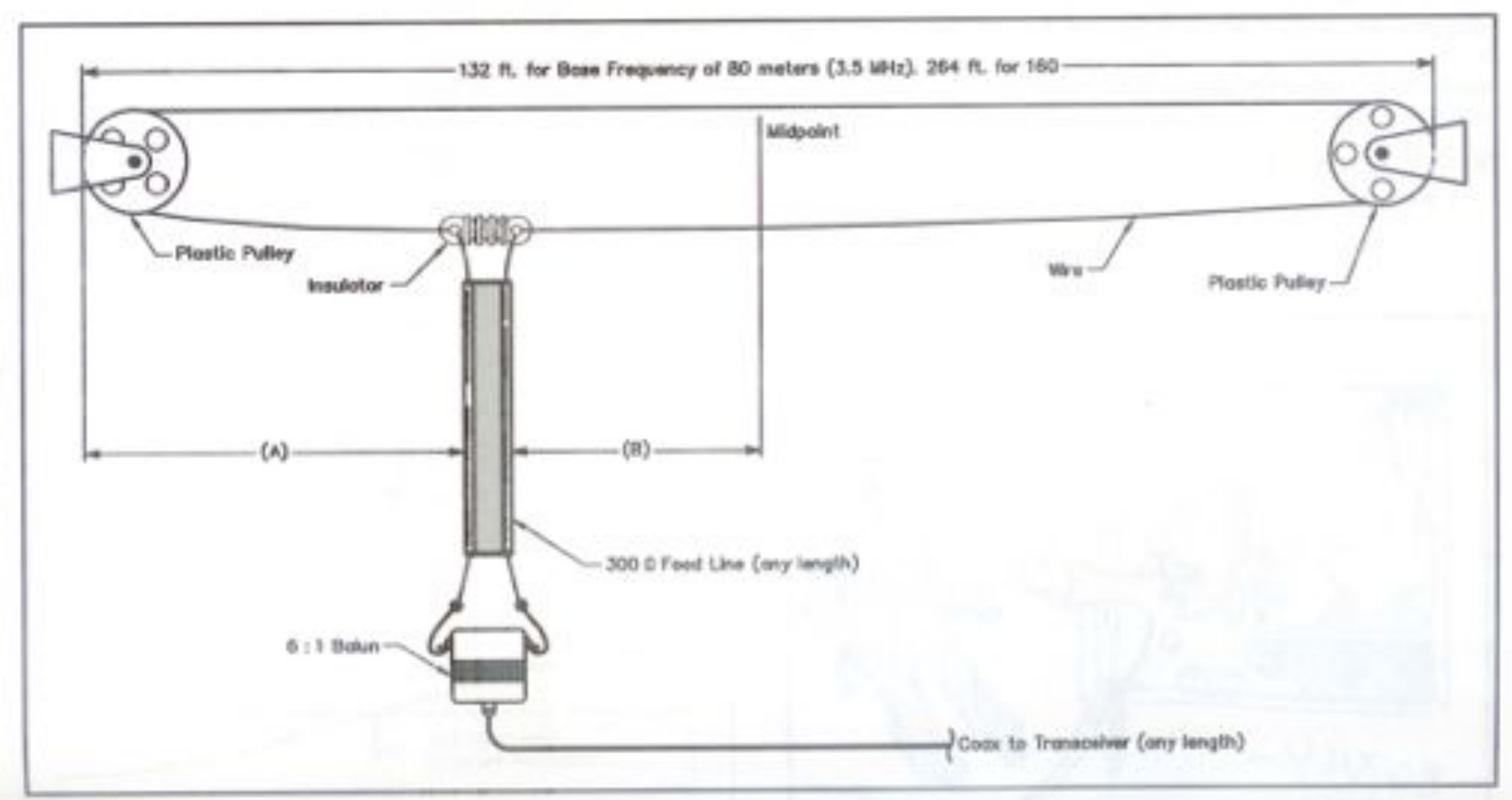
Dipoles vs. Folded Dipoles





- All have same radiation pattern
- Dipole Z = 72 ohms
- Folded Dipole Z = 300 ohms
- 3 wire Dipole Z = 450 to 600 ohms
- Multi-wire dipoles may require a balun and will require a tuner
- Multi-wire dipoles have wider frequency range with lower SWR

"Clothesline Folded Dipole"



G5RV Multiband Wire Antenna

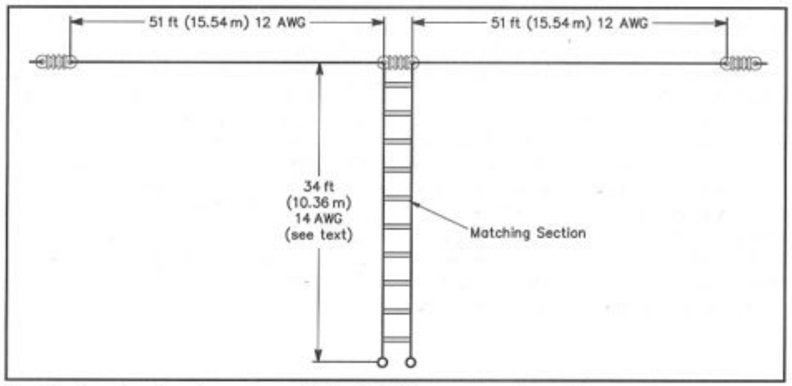
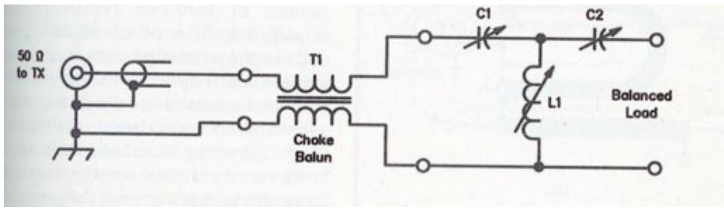
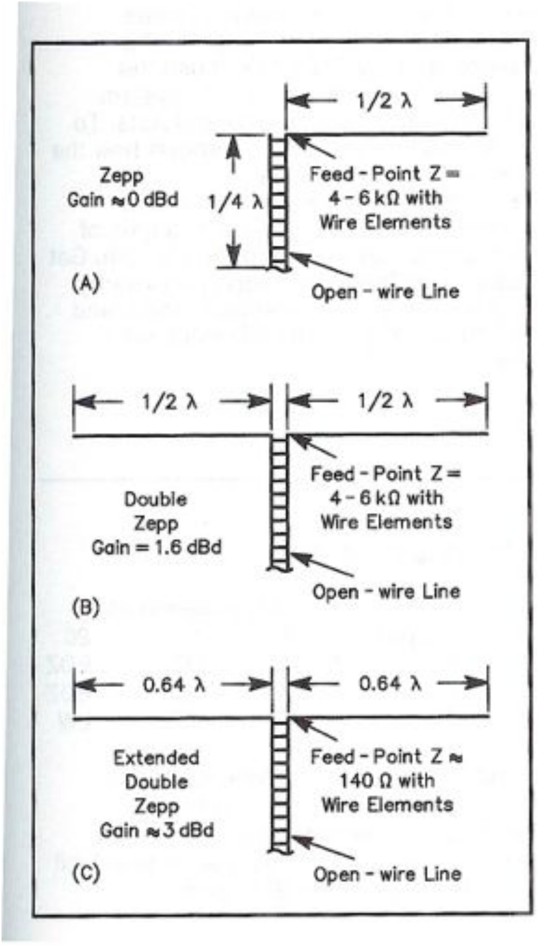


Fig. 9—Construction dimensions of the G5RV antenna and matching section.



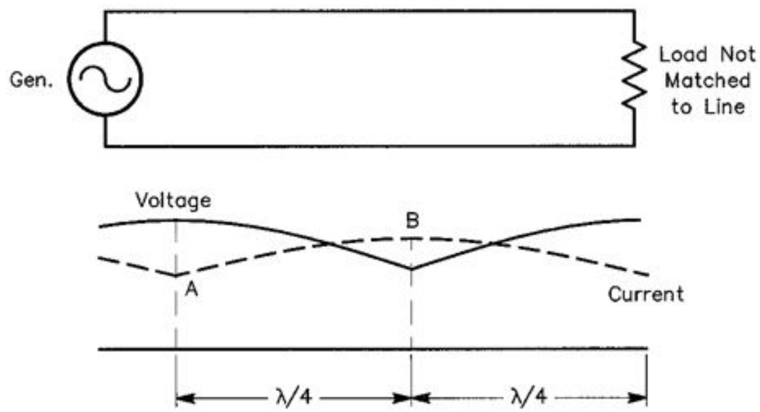
- 3.5 to 28 MHz
- 102 ft. center fed dipole with 34 ft open wire feeders
- Open wire feeders act as a matching section
- Requires use of tuner with balanced output

Zepp (Zeppelin) Wire Antenna



- Multi-band antenna
- Use length for lowest desired frequency
- More wire – more gain
- May require a balun
- Will require an antenna tuner

SWR



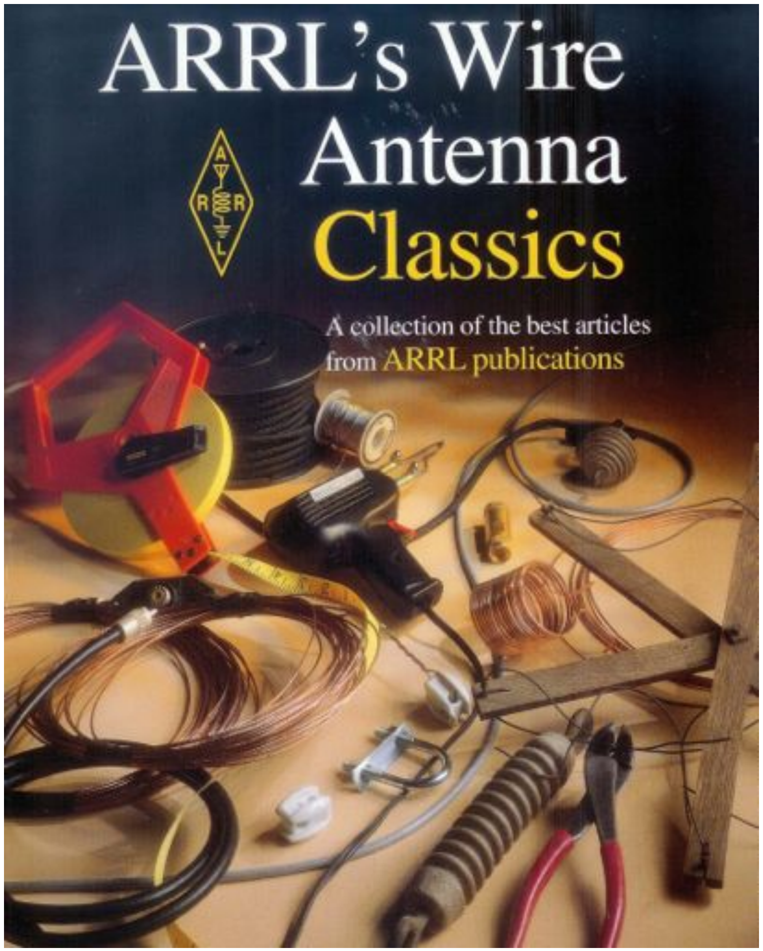
- Note that as the transmitted signal deviates from the antenna design frequency the antenna reactance and SWR increases
- Increasing SWR results in increasing losses in feed line
- Modern transceivers will reduce power when SWR is greater than 3
- SWR = E_{max} / E_{min}
- The forward and reverse power/voltage can be measured using a directional coupler

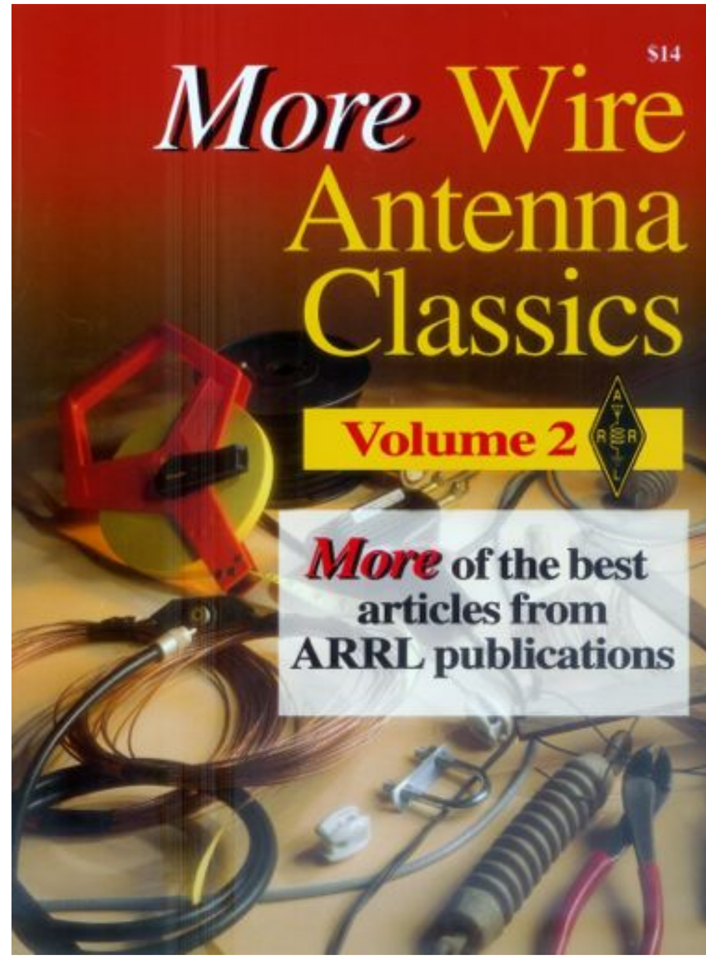
HF Wire Antenna

- Polarization
- Impedance
- Long Wire
- Loop
- Windom
- Vertical
- Antenna Tuners

- Dipoles
  – Simple
  – Sloper
  – Inverted “V”
  – Fan
  – Trap
  – Folded
- G5RV
- Zepp
  – End fed
  – Center fed

ARRL Wire Antenna Publications





By Rick Littlefield, K1BQT

A Wide-Range RF-Survey Meter

Find and measure the presence of RF energy over a 500-MHz range with this inexpensive, easy-to-build meter.

JOE BOTTIGLIERI, AA1GW

This handy RF-survey meter measures signal levels from –70 dBm to +10 dBm over a 500-MHz frequency range. The detector's wide response and pocket-size portability make it useful for design work and bench-testing, RFI hunting, EMR hazard detection, fox-hunts, surveillance sweeps and many other tasks around the shack and in the field—and it's cheap and easy to build!

Circuit Description

The heart of this project is U1, Analog Device's AD8307 wideband detector IC (see Figure 1). This eight-pin device is a specialized instrumentation chip that accurately reads RF levels over a huge 92-dB signal range, then generates a 0.5 to 2.5-V dc log-output signal to drive a signal-strength indicator. It works a bit like the RSSI (received signal-strength indicator) feature found on many FM receiver ICs, but covers a frequency range spanning VLF to over 500 MHz with a virtually flat response.[1] The IC's logarithmic output is important because it permits us to use a linear-scale voltage display to indicate signal strength in decibels (dB) or decibels referenced to a milliwatt (dBm)—just like a spectrum analyzer.

U1's output feeds an LM3914 LED driver (U2) that controls the meter's 10-segment color-coded LED array. The first LED lights with no signal present to function as a power-on and battery status indicator. The remaining nine LEDs illuminate sequentially, in 10-dB increments, as signal input increases over U1's 90-dB measurement range. U2 is configured in the bargraph mode, which means the LEDs illuminate collectively as the reading increases. This mode draws a bit more operating current than the single-LED mode, but yields a far more colorful and easy-to-read display. To compensate for increased current drain, a momentary press-to-test power switch is used to conserve power anytime measurements aren't being taken. I chose the solid-state LED array over an electromechanical meter because it delivers sufficient accuracy for casual survey work, and because it is virtually bulletproof.

Do you need greater resolution? The AD8307's accuracy is within 1 to 2 dB over its entire dynamic range and could be used to drive a more sophisticated display consisting of a dc-amplified large-scale meter or a recalibrated DVM module. For more complete technical information, data sheets and application notes are available at Analog Device's Web site: **http://www.analog.com/logamps**.

Construction

Nearly all of the parts required to build this project are readily available at your local RadioShack store or can be ordered via RadioShack's Web site **http://www.radioshack.com**. PC boards are available from FAR Circuits,[2] and single quantities of the AD8307s can be purchased from me.[3]

Assembling the meter is simple. The only tricky operation I encountered was mounting the LEDs at the correct height to mate with the panel openings. I solved this problem by making a small spacer-gauge from a scrap of PC board and slipping it under each LED during soldering. Spacing may vary slightly, depending on the LED manufacturer. The LED array is much easier to make if all the diodes are manufactured by the same company and have identical case styles. When mounting capacitors, lay C5 on its side so it clears the front panel. Use caution when installing U1. The AD8307 is static-sensitive, so use a wrist strap, a grounded soldering iron and standard CMOS-IC handling precautions.

Testing and Final Assembly

Perform the initial testing and calibration before mounting the PC board in its case. Attach a fresh 9-V battery to the snap clip. If you don't have a precision signal generator available, apply power and adjust the **ZERO** trim pot (R2) so only the first red LED illuminates. This will provide a rough calibration, and your meter will be

[1]Notes appear on page 44.

A Current Probe for the RF-Survey Meter

This little meter can be a useful accessory for the home experimenter. Microwattmeters can be quite expensive, even if they're used equipment. For example, this meter can be used to indicate the power from an LO in a receiver or transmitter design.

Microwattmeters also have other uses. With a small whip antenna (ie, a "rubber ducky"), the meter can be used as a relative field-strength indicator. With a rubber ducky, W1AW's signal registered at about half scale as I wandered, meter in hand, around ARRL HQ and the grounds. (HQ staff are used to seeing Lab personnel running around doing all sorts of weird things.) Be careful not to place the meter too close to an antenna, though; it is possible pick up too much RF and possibly damage the meter.

Several companies now sell hand-held current probes based on technology similar to that used in this project. Those probes have a current probe composed of a small clamp-on ferrite bead wrapped with a few turns of wire. The meter then can be used to accurately measure small RF currents and as a relative indicator of the amount of RF noise present on computer cables, the outside of a coaxial cable, telephone wiring, etc.

The commercial units I've seen have the ferrite probe mounted directly on the meter. Although this is handy, it can make the meter awkward to use in tight quarters. To measure noisy cables, I want something a bit more portable. I considered using various spring-type clamps available at hardware outlets, but they all seemed far too springy. As I strolled through the tool department at Lowe's, the Vise Grip clamp shown in Figure A caught my eye. The flat parts of the clamp seemed perfectly suited to the task I had in mind. The ferrite beads with plastic covers used here are available from Palomar Engineers, PO Box 462222, Escondido, CA 92046; tel 760-747-3343; **palomar@compuserve.com, http://www.palomar-engineers.com/** and from RadioShack (RS 273-104).

To build the probe, first trim the latch on the ferrite bead's plastic housing so that the sections no longer snap together. Use a few dabs of epoxy to hold each half of the bead to the Vise Grip clamp, as shown in Figure B. (Be careful not to get any glue on the ferrite material.) The clamp's flat sections are perfectly suited for this arrangement; other clamps don't have these flats. Once the glue sets, carefully pry out one ferrite section from the plastic housing. Wrap three to five turns of small enameled wire (#28 will do) on the bead half, leaving about 3/8 inch of wire for leads. Using a small dab of glue to hold it in place, press the bead back into its housing.

Remove about 3/16 inch of insulation from each of the probe's wire ends and solder them to a short length of RG-58 coaxial cable. Cover each lead connection with a length of heat-shrink tubing or insulated sleeving. Install a BNC male connector at the cable's other end. I used a couple of small plastic ties to secure the coax to the clamp; see Figures A and B. (For photographic purposes, I didn't add the heat-shrink tubing.) The probe is now ready to use.

To use the probe, adjust the Vise Grip clamp carefully so that the probe's ferrite sections *just* close when the clamp is squeezed. (Excessive closing pressure may damage the ferrite sections. Once the proper adjustment point is reached, consider locking the adjustment screw in place with epoxy or using a jam nut.) Clamp the probe over the cable you're checking. With four turns of wire on the bead, the cables on several computers at HQ just lit the meter's yellow LEDs. Significantly noisier computers lit the meter's red LEDs, indicating that those cables could be a source of RFI. If desired, you can calibrate the probe/meter combination using a signal generator and a 47-Ω resistor to create a known current.

Microwattmeters can be useful pieces of test equipment for the RF designer. New microwattmeters cost several thousand dollars. This project can get you nearly the same performance at a lot lower cost.—*Ed Hare, W1RFI, ARRL Laboratory Supervisor*

Figure A—A handy probe is made by attaching the two halves of a modified ferrite core to a Vise Grip clamp. Plastic ties secure the cable to the clamp.

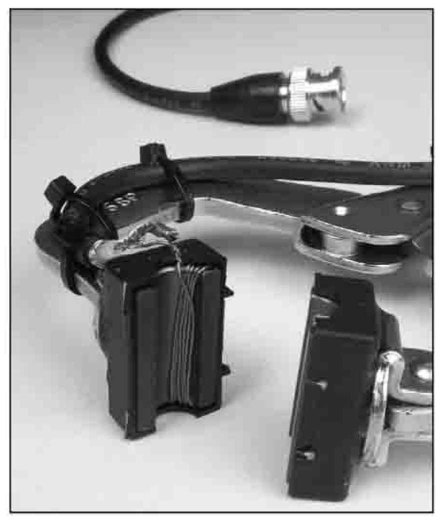


Figure B—Close up view of the modified ferrite core wound with a few turns of enameled wire.

Table 1
Signal levels falling within the survey meter's range span a 90-dB range.

Power (dBm)	*Power (W)*	*Approximate Potential Across 50 Ω*
+10	10 mW	1 V
0	1 mW	300 mV
–10	100 µW	100 mV
–20	10 µW	30 mV
–30	1 µW	10 mV
–40	100 nW	3 mV
–50	10 nW	1 mV
–60	1 nW	300 µV
–70	100 pW	100 µV

reasonably accurate for most survey tasks.

If you have access to a signal generator, install two short leads on the BNC connector and tack-solder them temporarily to the PC-board-input connections. With power applied and nothing connected to the BNC connector, adjust R2 so the first LED illuminates. Then, set the generator for CW output at 100 MHz and connect its patch cable to the BNC jack. Reset R2, as needed, so the last LED just illuminates with +10 dBm of signal applied. When calibrated, reducing the generator's output in 10-dB increments should extinguish one LED per step. If the bargraph reading doesn't change reliably with each step change between +10 and –60 dBm, reset R2 slightly until it does. Note that the low-level green LED (–70 dBm) may remain on continuously because of stray RF pickup on the generator cable.

Once alignment is complete, remove the BNC connector and install the PC board in its case. Secure the PC board in position by the **POWER** switch, omitting the switch's lock washer when installing. Make sure all LEDs are seated in the case openings before fully tightening the switch's mounting nut. Install the BNC connector in its panel and, using short leads, permanently connect it to the PC board.

Operation

Avoid connecting this meter to signal sources more powerful than +20 dBm (100

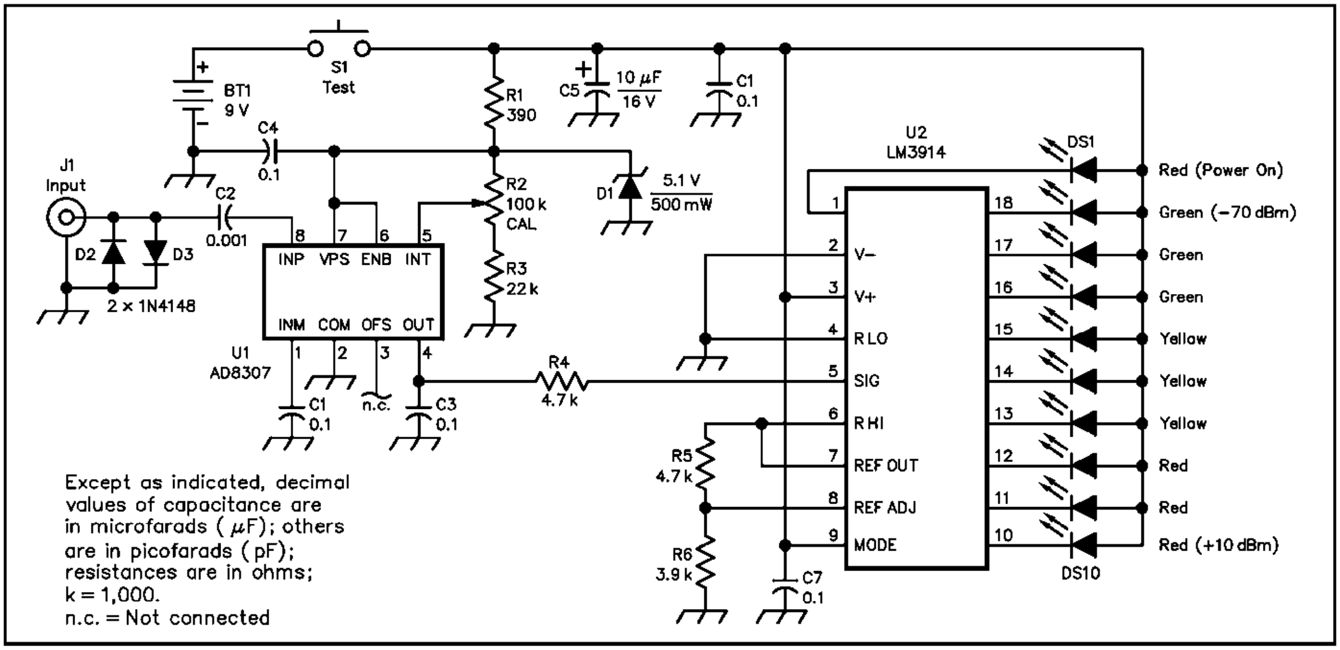


Figure 1—Schematic of the RF-survey meter. Unless otherwise specified, resistors are 1/4-W, 5%-tolerance carbon-composition or film units. Part numbers in parentheses are RadioShack; numbers with 900 prefix are for RadioShack's on-line catalog (http://www.radioshack.com). Equivalent parts can be substituted; n.c. indicates no connection.

C1, C3, C4, C6, C7—0.1 µF disc ceramic
C2—0.001 µF disc ceramic
C5—10 µF, 16 V electrolytic or tantalum
DS1, DS8-DS10—3 mm LED, red (900-6085)
DS2-DS4—3 mm green LED (900-6086)
DS5-DS7—3 mm yellow LED (900-6087)
D1—1N5231B, 5.1 V, 500 mW Zener diode (900-3088)
D2, D3—1N4148
J1—BNC chassis mount connector (RS 278-105)
R2—100 kΩ, 6-mm horizontal-mount trim pot (RS 271-284)
S1—SPST momentary, normally open switch (RS 275-1571)
U1—Analog Devices AD8307
U2—National LM3914 (900-6840)
Misc: Case—2 3/4×4 5/8×1-inch (HWD) box with 9-V snap clip (RS 270-211)

mW) without first installing an attenuator or sample tap to reduce the input to a safe level. To operate your meter, press the TEST switch and observe the bargraph display. If the lowest segment fails to illuminate, check the battery condition before proceeding. The meter draws approximately 20 mA (depending on how many LEDs are lit), so frequent use will necessitate periodic battery replacement.

When making measurements, remember this is a basic survey tool designed for gathering ballpark indications rather than precise data. Also, as with any broadband device, it cannot discriminate between narrowband and wideband energy sources or tell you the frequency of an applied signal. Finally, remember that the dBm is a unit of RF power referenced to a 50-Ω load. The unterminated input impedance of U1 is approximately 1 kΩ at 100 MHz, so readings taken across unknown loads will be *relative* indications that are comparable in dB, but not absolute values in dBm.

Summary

This simple hand-held project uses a low-cost instrumentation IC to detect the presence of RF energy over a 500-MHz range. Approximate signal intensity is displayed on an easy-to-read LED display, and a wide range of sampling attachments may be used for picking up signals. I find I use it often, both on the bench and in the field, whenever I need a quick "reality check" for the presence of RF. It's especially useful for tracking down RFI sources, as Ed (W1RFI) Hare's sidebar, "A Current Probe for the RF-Survey Meter," illustrates.

Notes

[1]Rick Littlefield, K1BQT, "The Analog Devices AD8307 92-dB Logarithmic Amplifier," *Communications Quarterly,* Summer 1999, pp 77-80.

[2]A PC board is available from FAR Circuits, 18N640 Field Ct, Dundee, IL 60118-9269, tel 847-836-9148 (voice and fax). Price: $4 plus $1.50 shipping for up to four boards. Visa and MasterCard accepted with a $3 service charge; **http://www.cl.ais.net/farcir/**.

[3]Contact the author for information.

Rick Littlefield, K1BQT, is an Extra Class licensee and active ham since 1957. An avid builder, RF-product designer and author, he's written for a wide range of Amateur Radio publications since 1969, and was inducted into the QRP-ARCI Hall of Fame in 1996. Rick holds a Master's Degree from the University of New Hampshire and currently works as a technical writer in the electronics industry. You can contact Rick at 109A McDaniel Shore Dr, Barrington, NH 03825; **k1bqt@aol.com**.

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Next New Product

The “Tree Antenna”
RCC Aug & Oct 2006 – Dave/WB7ESV

Aug 2006 Article

What is unique about this antenna is that it is only a tree. The tree is used as a Gamma or Shunt fed vertical. To make this work, we drove a 3 ½” deck screw into the tree (you need to make contact with the sap vein), at about 15’ above the ground (15’ to 20’ will work). We attached a wire to the screw, extended the wire 2’ perpendicular to the tree, tied a rope to the wire at the 2’ point, tied the other end of the rope to a tree limb and dropped the wire to the ground.

At the ground we drove a 3’ ground rod 2 feet out from the base of the tree and attached a rope to the ground rod and to the wire to keep the wire tight.

At the feed-point end of the wire we connected an MFJ-901B tuner strapped for “WIRE” operation and connected the tuner ground to the ground rod.

Coax was connected and run to the operating position in a tent. To tune the antenna, an MFJ-269 SWR Analyzer was connected to the tuner input and the tuner adjusted for minimum SWR at the center of the operating band. The antenna is capable of operation on 10 - 80 meters. Many contacts were made including: Hawaii, Texas, Oklahoma, Montana, Wyoming, Utah, Idaho, California, VE6 and VE7.

The tree height should be no shorter than 30 feet and any wire antenna tuner will work.

Oct 2006 Article

Those who are building or have built it are: Jeff, KB6IBB, in The Dalles, OR; Tom, KD7ZOS, in Portland, OR; Dave, W0OXB, in Stillwater,MN; and Larry, KE7HGC, in Vancouver, WA.

Those who have it up and running have made contacts all over the U.S. and have stated that: .If I can hear them, I can talk to them.

If you are in an area that frowns on antennas and you have a tree that is at least 30. tall, give it a try. What you will need to build the Tree Antenna is: A tree that is at least 30’ tall, a 3# nail or wood screw, (not galvanized), 20’- # 12 - # 16 AWG copper wire (can be solid or stranded, un-insulated or insulated), a 4’ ground rod, wire clamp for the ground rod, 2-egg insulators and an antenna tuner that can be remotely adjusted, (ICOM AH-4, SGC SmartTuner, Home Brew with small motors to operate the variable capacitor(s) and inductor, etc). If you decide to ‘Home Brew’ a tuner, there are several in the ARRL Amateur Radio Handbook that will work very well.

Solder one end of the copper wire to the nail/screw. At about 15’- 18’ up the side of the tree drive the nail/ screw into the tree so as to penetrate the sap vein of the tree. (This is important for RF conduction.) Draw the wire out 2’ perpendicular from where you drove the nail/screw and support the wire with an egg insulator tied to a rope which is tied off to a limb of the tree and let the rest of the wire drop down to the ground.

Drive the ground rod into the ground 2’ out from the base of the tree leaving about 3’ of the rod above ground level. Attach a short piece of rope to a egg insulator and attach the other end of the insulator to the copper wire so that the insulator/wire is about 6’ above the top of the ground rod. Leave enough wire to connect to the tuner.

Attach a short piece of rope to a egg insulator and attach the other end of the insulator to the copper wire so that the insulator/wire is about 6’ above the top of the ground rod. Leave enough wire to connect to the tuner.

Attach the rope to the ground rod and install the antenna tuner to the end of the wire and place the tuner in a plastic container to protect it from the weather.

Connect a short ground wire from the ground side of the tuner to the ground rod with a clamp and make sure all connections are tight and sealed from weather.

If you are wondering where the “Tree Antenna” Comes from, it’s from a WWI/WWII Army Signal Corps Emergency Communications Manual.

A Tree Antenna for the 600 Meter Band

Sept 8, 2007 - By W5JGV (updated January 01, 2008)

"Why put up an antenna when they're growing all around you?"

There are two antennas in this picture and one of them is not made of metal. Can you find them both?

If you look carefully, you can just see the horizontal single wire antenna in the background in the far right side of the picture. That is my 160 meter dipole antenna, which is about 20 feet above the ground. The other antenna is the large Oak tree in the center of the picture. Near the base of the tree trunk is the coupling coil which surrounds the trunk.

Yes, the tree IS the antenna!

My interest in tree antennas goes back many years, when I first read about some experiments using coils to couple RF energy to trees. Unfortunately, I neglected to save the article, and it was only much later that I was able to locate the source for the article.

Here are four articles that explain tree antennas - George O Squire Tree Antenna Patent.pdf - 1975 January Ikrath IEEE tree antennas.pdf - Robert Hand article.pdf and Signal Propagation at 400 kHz Using an Oak Tree with a HEMAC as an Antenna AD735330.pdf

It appears that there are two methods generally used to connect to a tree for using it as an antenna. The first is to drive a nail into the tree some distance up from the ground, and the second is to use a coupling coil around the trunk close to the ground. Since I prefer not to climb trees unless I really have to, I decided that the coupling coil would be the better approach.

Since little, if any, design data has been published on tree antenna coupling coils, I took a guess at what might work for the coil dimensions. I guesstimated that using a coil with about half the diameter of the tree trunk would be about right for the coil diameter. The length of the coil would be the diameter of the tree trunk. The number of turns was an unknown, but I figured that if the inductance was too small the tuning would be very sharp, and changing environmental conditions, rain, temperature, etc., might cause tuning problems. A larger inductance would be less sensitive to such things.

I decided on an inductance of about 175 uH as a starting point. That would require a coil of about 75 turns of about 10 inch diameter, or a total of about 195 feet of wire. Since I had a lot of #10 AWG bare copper wire available, that was used for the construction of the coupling coil.

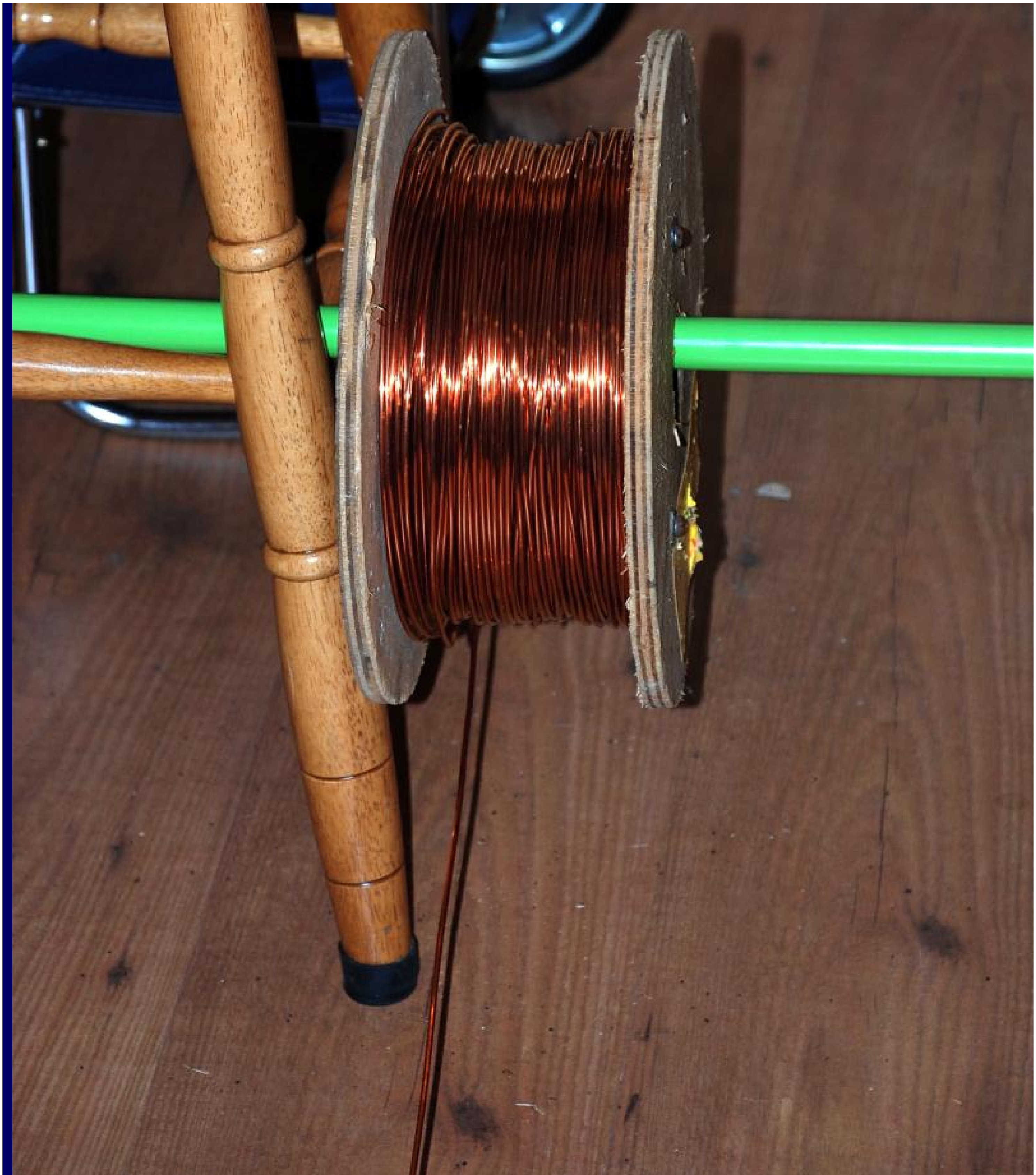
Tuning the coil to resonance at 505 KHz would require approximately 575 pF of capacitance. At resonance, the coil losses would be about 10 Ohms, which would not be too good for transmitting, but for receiving, it should not pose a problem. At resonance, the impedance of the circuit would be about 30 Kohms so it would be a fairly good match for FET RF preamplifier.

Designing the coil was one thing, but how was I going to hold it in place against the tree? It had to be held away from the bark, or losses would increase when the tree got wet in the rain. After wearing out several pencils and using up the back of a lot of old envelopes, I finally hit on the idea of dropping each turn of the coil into a series of parallel slots cut into a length of plastic pipe. Then, when I bent the pipe around the tree, the flexing of the pipe would cause the slots to close up slightly and squeeze the wire tightly between the sides of each slot. At

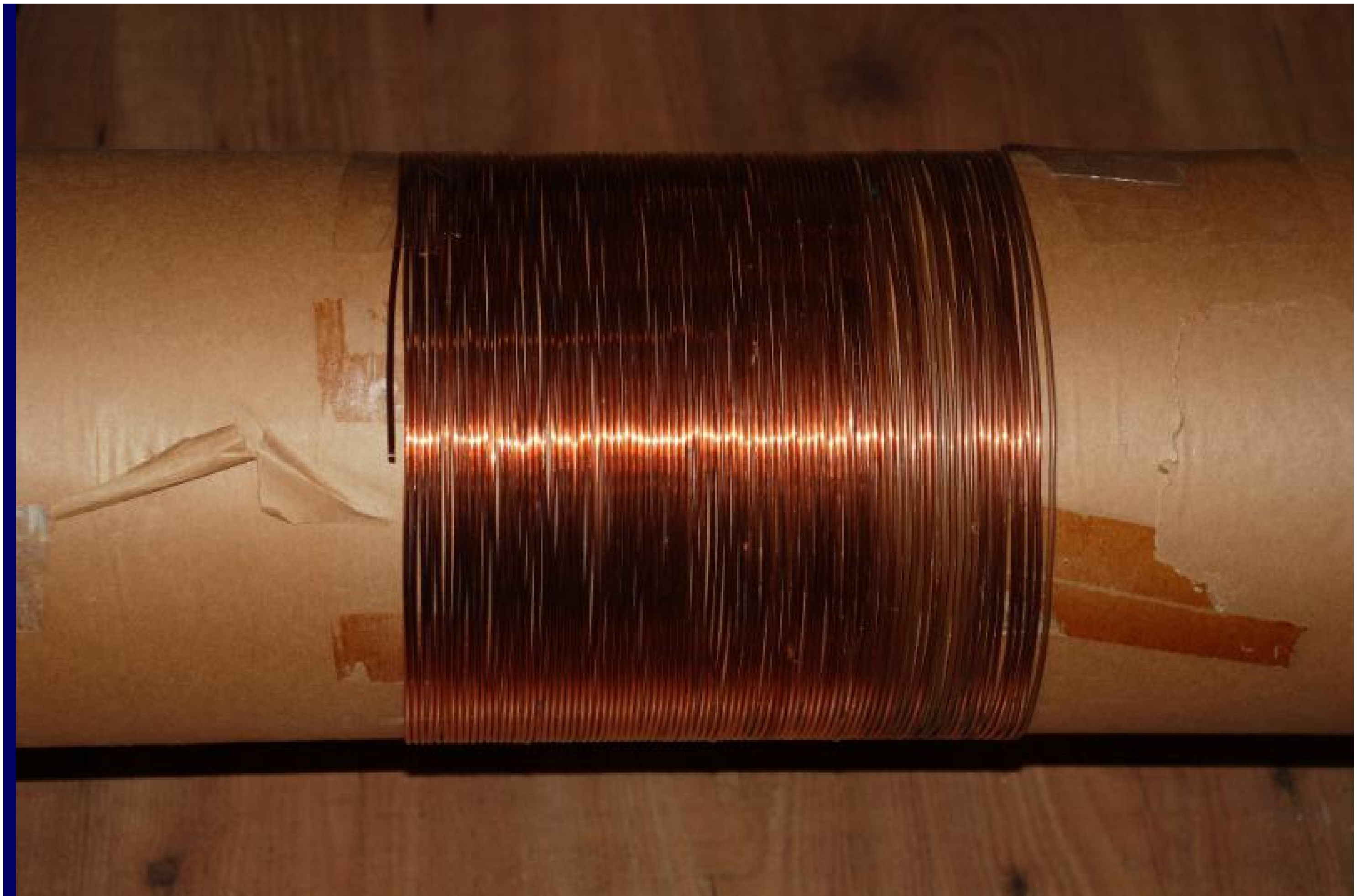
that point, all I'd have to do was to manhandle seven feet of flexible pipe and a hundred loose turns of copper wire into place while screwing the whole thing firmly to the tree trunk. I figured I'd work on that little problem after the coil was built.

Time to start construction!

Construction of the coupling coil was started by running a broomstick through a roll of Bonnie, KB5YSE's art studio wrapping paper and supporting the roll between two wooden chairs. The roll measures about 9 inches in diameter, and made a solid form on which to wind the #10 AWG bare copper wire for the coil. The free end of the wire was simply taped to the roll of paper and winding was begun. After about 90 turns were wound on the form, the coil was carefully removed from the form and set aside for later installation.



The wire I used was left over from a commercial AM broadcast antenna installation I did many years ago. It is bare, soft drawn, #10 AWG pure copper wire. It was just right for a coil of this size, since it is strong enough to hold its shape without any extra support.



Here is the finished winding while it is still on the winding form. It looks neat at this point, but as soon as I loosened the wire to remove it from the form, it promptly sprang into action and unwound into a larger diameter shape, and instantly piled up into what appeared to be a massively tangled heap! Fortunately, it was very easy to unravel, and placement of the wire coil onto the supporting tube went along without any unexpected difficulty.

All that wire has to be supported somehow, and I figured the easiest and cheapest way would be to take a length of 1" diameter plastic pipe and cut an evenly spaced series of slots into the pipe. As the pipe was bent around the tree and fastened in place against the tree, the slots would close up slightly as the pipe was bent. This would "put the squeeze" on the wire and hold the coil firmly in place. I drew a series of pencil marks spaced one inch apart on the pipe. The slots were then cut a little more than halfway through the pipe using a carbide tipped saw blade on a table saw. I made a "sled" for the saw to hold the pipe tightly in position as I cut the slots. The use of the sled also kept my fingers well away from the saw blade during the cutting process.

Well, here's the coil in place around the trunk of the tree. I'd like to say that the uneven placement of the ends of the tube were to ensure proper drainage of water from the tube when it rains, but in reality, I just screwed up a bit and didn't line things up quite right. (Hmm... I think I like the rain drain idea better!)

Seen from the other side of the tree, the coupling coil looks a bit better. The black screws that hold the pipe against the tree are not tightened up snugly. You must allow some slack here, or as the tree grows it will crush the pipe and eventually pull the screws right through the pipe, ruining the coil.

In this top view of the support pipe, you can see how the slots close up as the pipe is bent around the tree. As the slots close up, they pinch the turns of the coupling coil tightly. After the pipe is fastened in place, you cannot pull any of the turns through the slots. It's tight! The difficult part is that each turn of wire must be hand adjusted as the turns are placed into the slots. Of course, while I was doing this, about six other turns were trying to jump out of their slots. It turned out to be a real "juggling act" to get the turns to stay in place as I assembled the coil, but I finally beat the recalcitrant coils into their proper positions; order prevailed, and I got the coil finished at last.

Tune up time! Does it actually work?

A quick test setup was made using a portable radio and an old 435 pF dual section variable capacitor salvaged from a defunct broadcast receiver. The coil resonated with the calculated amount of capacity connected across it. As it eventually turned out, this was about the easiest way to tune the antenna. All I have to do is to position the portable radio antenna close but not touching the coupling coil. The radio is then tuned to the frequency at which I want to tune the antenna. When the coupling coil is tuned to resonance, the signal (or background noise) in the radio increases, indicating that the system is tuned to resonance at that frequency.

After the first tune up was so successful, I quickly constructed the elaborate weather cover you see here. Slits were cut into the bottom of an empty plastic water bottle and the tuning capacitor and feedline connections were stuffed into the bottle. This setup, complete with the Radio Shack clip leads, was used for several days before a more permanent enclosure was installed.

Now, this looks more like it! The enclosure is one that I salvaged from my Katrina-ravaged tower at my old QTH in New Orleans. The cabinet is at least 30 years old (Hoffman makes good stuff, you bet'cha!) and has been out in the sun and rain all those years. It is still weather tight using the original gaskets. It is Fiberglass and was starting to shed glass strands, so I refinished the outside of the enclosure.

There are two connections visible on the left side of the enclosure. The connection closest to the tree goes to the left ("cold") end of the coupling coil. This end of the coil is also connected to ground. The front-most connection goes to a tap on the coil that is 10 turns from the ground end of the coil. This is the feed point for the 75 Ohm coaxial cable that goes to the receiver in the shack.

A close-up view of the tap and cold end of the coil connections.

Stainless steel through bolts carry the signals through the Fiberglass walls of the enclosure. Sealer is applied to the bolts so that rain will not enter the enclosure. The bolts that hold the enclosure against the tree are not snugged up tight, there is room for the tree to grow. Both the bolts holding the enclosure to the tree and the screws holding the coupling coil in place will have to be backed out slightly every year or so.

The ground system for the coupler uses three steel screws that are driven into the roots of the tree. I figured that the tree probably has a better connection to the ground than I could manage to get by driving a ground rod. After running the screws into the roots, the screws are removed and the end of an aluminum wire are pushed down into the holes. The screws are then replaced. This gives a good connection to the damp wood. Do NOT drive copper or brass wire or screws into a live tree, as the copper may kill the tree. Iron, steel or aluminum is OK.

At the center ground-root, the wires from the other two ground-roots and the twisted pair of ground wires from the coupler circuit all come together. All the wires go about two and a half inches into the tree root. I used aluminum electric fence wire for the ground wires.

The ground wire goes from the tree roots to the coaxial connector on the bottom of the tuner enclosure.

A split-bolt wire connector connects the ground wire to the pigtail coming from the connector.

As you can see, the enclosure is mostly empty space. A much smaller cabinet could be used, but this one was available and didn't cost me anything

The frame of the tuning capacitor is simply bolted to an aluminum angle bracket and fastened directly to the grounded through bolt. Since the capacitor frame is grounded, I cam simply grab the dial cord drum on the end of the capacitor shaft and turn it as needed to adjust the capacitor.

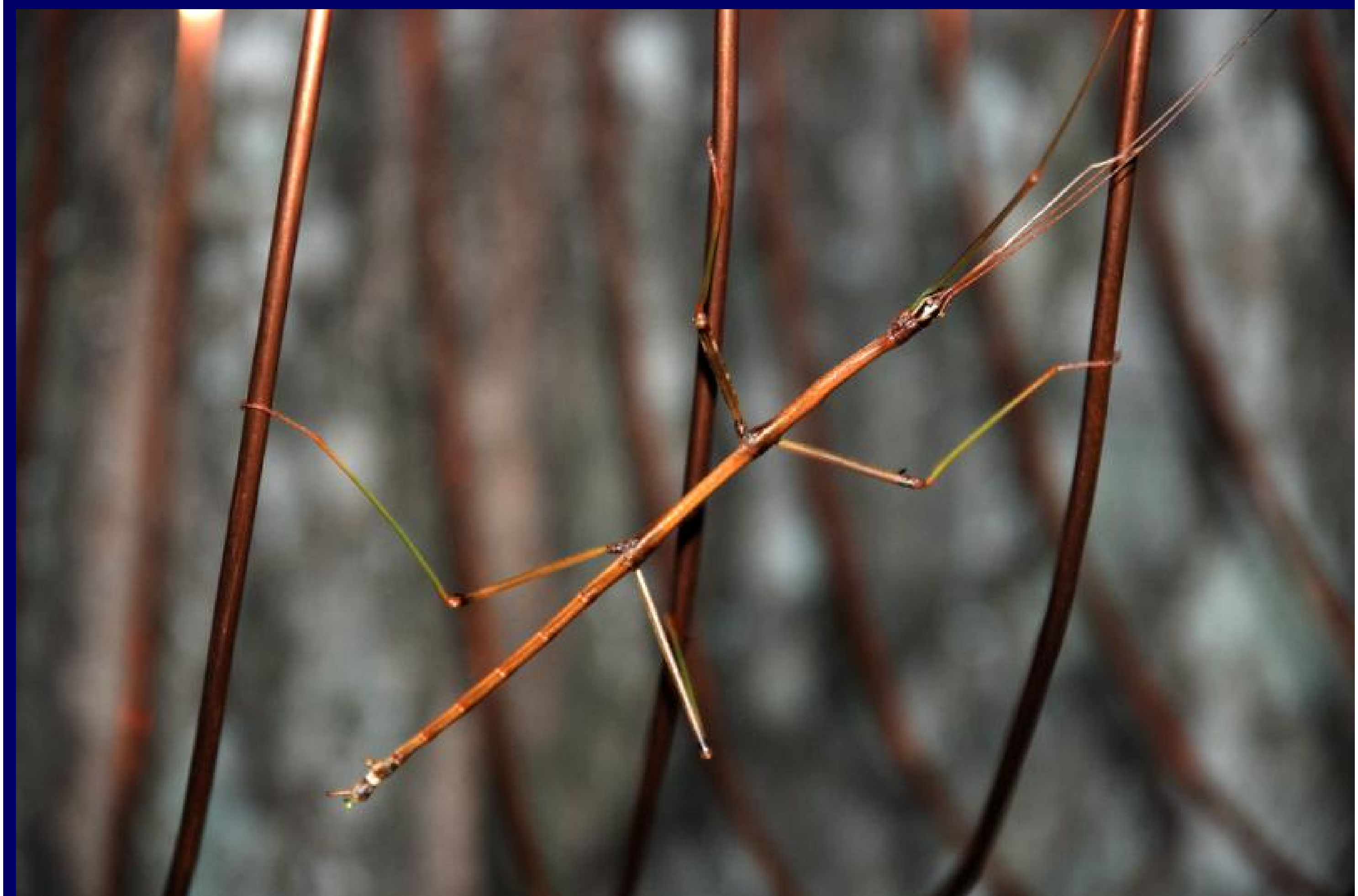
Both sections of the capacitor are in parallel, and connected to the wire leading off to the right of the picture. That wire goes through a ceramic feedthrough insulator on the right side of the enclosure and then connects to the hot side of the coupling coil.

The wire closest to the back of the cabinet is the ground wire between the cold end of the coupling coil and earth ground. The wire nearest the front of the cabinet connects the coil tap to the center wire of the coaxial cable going back to the shack. Two spacers made from vinyl plastic tube that were used to hold the parallel wires in place.

I had previously installed this 100 uH coil in the enclosure to be used as part of a shunt feed tuned for my old tower on 75 Meters.

However, even after much tinkering, it never worked properly, so I abandoned that project. It was only after removing the coil to refinish the enclosure for this tree antenna project that I realized that the cause of the problem was. It seems that when I wound the coil, I covered the winding with what apparently was a VERY good clear varnish, because it prevented the E. F. Johnson squeeze clips that I used from making contact with the wire! No wonder it would not work!! All I can figure out is that I must have had total brain fade when I built the tuner. I left the coil in the enclosure, since it just looks so nice. <G>

Except for the RF preamplifier, this is the finished system. I simply ran the coax cable over the ground and back to the shack. It's easy to change if I need to, and the lawn mower misses it. In a year or so, the grass will have grown over it and it won't be noticeable.



While working on the tuner, I noticed this little guy walking across the turns of the coupler coil. If he had been parallel to the turns, I probably would never have noticed him.

CLOSING THOUGHTS -

- The tree I chose for this project is about 90 feet tall. There are others available that are taller, or more in the clear, or both, but this one was in a good spot for testing. It is far enough from the house so as not to pick up

much "house noise" but close enough so that I can get a long extension cord out to it to run test gear. I may try a different tree at some point.

- I suggest using aluminum electric fence wire or aluminum clothes-line wire for making the coil. That would make the coil lighter and easier to handle during construction, and the losses in the coil will not be enough greater to worry about. One advantage of the #10 bare copper wire is that it fits perfectly in the slot cut by the circular saw blade. Other types of wire may require a different width slot and considerably more construction effort.

- I strongly suggest that you drill the holes for the mounting screws through the plastic support pipe BEFORE you try to attach the coil to the tree, unless you have at least six hands to hold everything.

- Having an extra person available when you attach the coil to the tree is a great help. I did it all by myself, but I waited until the dark of the moon, on a Tuesday, and I held my tongue >just< so. ;)

- I did not use any isolation transformers between the coupling unit and the coax feedline going back to the ham shack. I did not see any extra noise pickup from the coax cable either with or without the cable grounded at the tree end of the cable. Your installation may be different, of course. I happen to have (finally!) a very low RF noise QTH.

- This coupling coil was designed for MF operation. The tuning range of the coil with the capacitor I used is from roughly 428 KHz to 1150 KHz. No detuning of the system is noticed unless you bring your hand within a few inches of the hot end of the coil. A coil with fewer turns would probably work better for HF work.

- The signal pickup of the tree antenna seems about equal to or a little less than using one side of my 160 meter dipole antenna, which is about 20 feet high. It does seem to pick up a little less noise than the dipole, so the S/N ratio appears better overall. I have not had the tree-tenna in use long enough to make any accurate conclusions.

- I have not noticed any difference in signal pickup from day to night, nor does rain seem to change the antenna characteristics.

- Tuning of the antenna may be done by using the variable capacitor or by shorting out one or more turns of the coil on the "cold" end. This raises the operating frequency but does not seem to change the sensitivity of the antenna appreciably. Since the "cold" end of the coil is grounded, a simple relay arrangement may be used to short out some of the coil turns to ground to make frequency shifts remotely.

- The antenna works even better since I installed my RF preamplifier.

73,

Ralph - W5JGV - WD2XSH/7

[BACK]

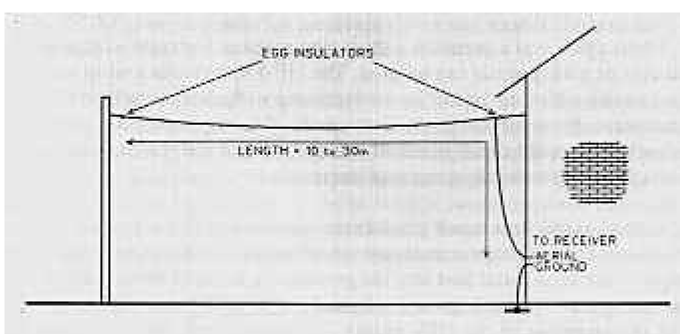
ANTENNA
TUNING UNITS
(ATUs)

ATUs - ANTENNA TUNING UNITS

THE ATU

An Antenna Tuning Unit

For good Short Wave reception long aerial really is required to dig those distant stations out of the ether. To effectively couple such an aerial to a radio a matching unit called an ATU (Antenna Tuning Unit) can often be extremely helpful. An ATU is relatively straightforward to construct and uses simple parts that are quite easy to obtain. The ATU shown above is of my own construction and is used with a Lowe HF-150 receiver.



Typical Aerial Installation

AERIALS [or ANTENNAS]

AERIAL n. & adj. > n. a metal rod, wire or other structure by which signals are transmitted or received as part of a radio or television transmission or receiving system. > adj. 1. by or from or involving aircraft (aerial navigation; aerial photography). > 2 a existing, moving or happening in the air. b of or in the atmosphere, atmospheric. 3 a thin as air, ethereal. b immaterial, imaginary. c of air, gaseous

For the purpose of this page we'll choose the noun, I think. So the aerial can be:

A Random Length Of Wire Strung As High As Possible
OR -
A Carefully Designed Structure Whereby The Element (Or Elements) Is (Are) Tuned To Resonate At The Required Operating Wavelength (Frequency) Of The Station Or Waveband Being Received

(What??)

The advantage of a long random wire aerial to a listener is that it is easy to install in a loft or around a garden. Many Short Wave Listeners' (SWL's) aerials consist of such a long end fed wire of a random length perhaps between 10 and 50 meters, i.e. not cut to resonate at a specific wavelength. The disadvantage is that it is not tuned to a specific wavelength and therfore may not be particularly efficient at gathering the signals from a desired station. This is because a random wire aerial system will not present an even impedance* to the input of the radio receiver. This should generally be around 50 Ohms.

[* Impedance is the resistance to the flow of an alternating current (AC) - in this case a radio wave]

The impedance of a random wire aerial could swing from a few Ohms up to several thousand Ohms depending on what frequency is being used. This will present a serious mis-match to the receiver, which would prefer to 'see' a nice constant 50 Ohm load. This mismatch of impedance between aerial and radio can detrimentally effect the amount of signal transferred from the aerial to the radio, and therfore weaken reception of stations at some wavelengths.

An Antenna Tuning Unit (ATU) can help match the impedance of the aerial to the 50 Ohm impedance required by the radio. Once the impedance of the aerial matches the impedance at the input of the radio (after being tuned by the ATU) the greater the chance of the RF energy being effectively transferred.

Using an ATU will not always improve reception. If, by pure chance, the random wire aerial presents a 50 Ohm impedance to the radio on, say, the 41 meter band then no further improvement in signal strength will be obtained. But then if the radio is tuned to the 25 meter band, for instance, the aerial may have a 500 Ohm impedance and on this band the ATU will help to transfer more signal and improve reception.

WAVELENGTHS AND FREQUENCIES

This is the mathematical formula to calculate the wavelength of a particular frequency:

V/F = wavelength

E.G: V/F = 300,000,000/1,875,000Hz = 300/1.875MHz = 160m

The velocity of a radio wave when travelling through space is the same as the spped of light

i.e. 300,000,000 meters per second (186,000 miles per second). V = Velocity, F = Frequency in Hz. The result of the calculation is the wavelength in meters.

Once the wavelength of the radio wave is known, the relationship with the length of the aerial can be determined. An aerial that is 1/4 wavelength or an odd multiple of 1/4 wavelengths e.g. 5/8th or 7/8th wavelength, the impedance presented to the receiver will be quite low. If the aerial is a full or half wavelength long then the impedance will be much higher.

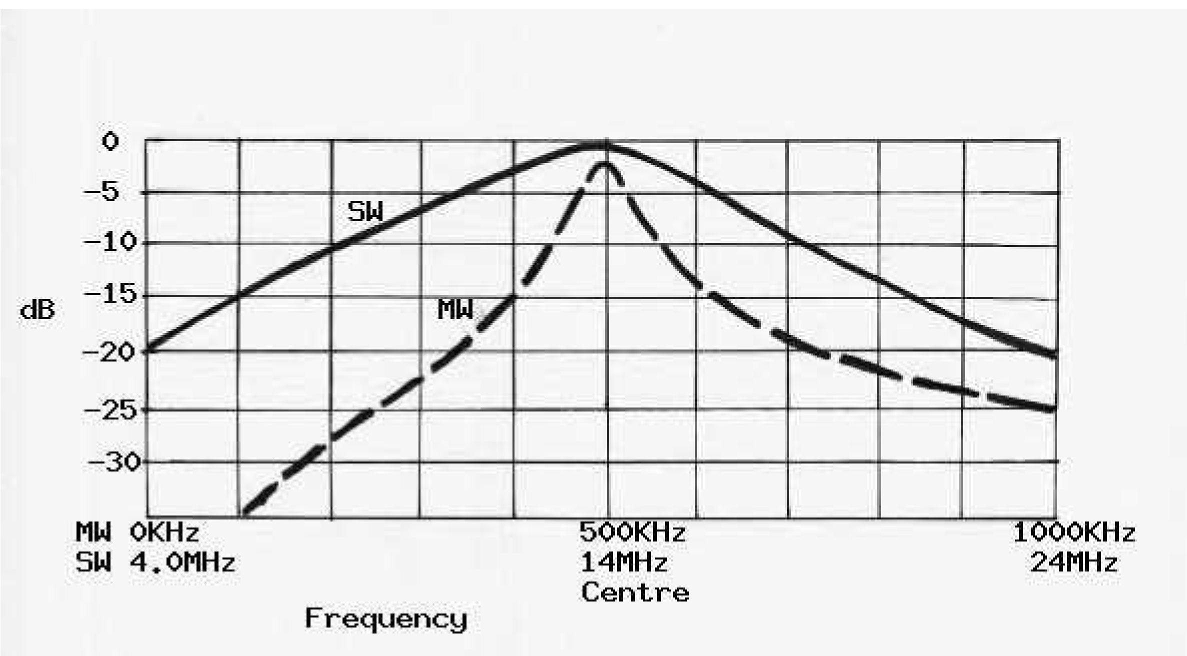
LOWE, JOHN WILSON AND THE SIX BAND SAGGER

Have a little look at the bottom of the LOWE HF-150 page since it includes an interesting article by John Wilson, formerly of Lowe Electronics, about aerials, specifically the "Six Band Sagger".

ATUs AND FILTERING

The ATU acts as an Impedance Matching Transformer with the ability to accept a wide range of input impedances and match them to the 50ohms that is required by the receiver. It also has the bonus of providing an certain amount of filtering, which can help overcome receiver overloading, by letting through the required frequency while attenuating the higher and lower frequencies. There are two types of ATU circuits described further down this page, the Pi type and the T type. The T type is particularly effective as a 'high pass' filter, and is very useful for filtering out interference on Short Wave caused by high power Medium Wave transmitters that can overload a short wave radio.

The graph below shows the effect that can be acheived:

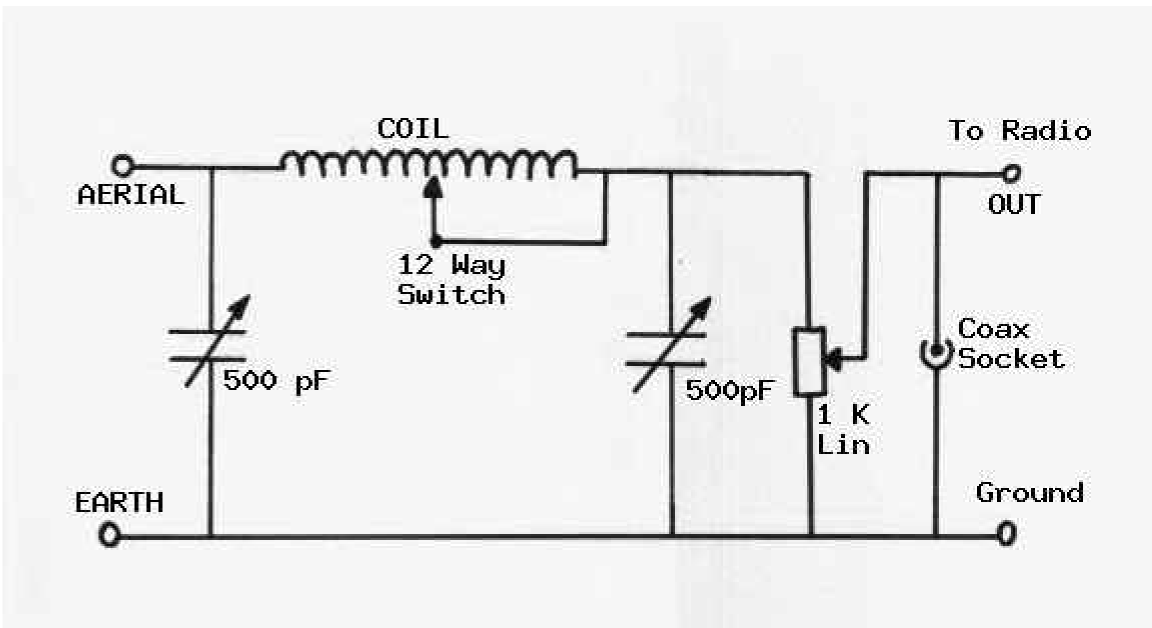


The solid line shows the filtering effect of an ATU at shortwave frequencies, while the broken line shows the filtering performance at medium wave frequencies

MAKE YOUR OWN ATU

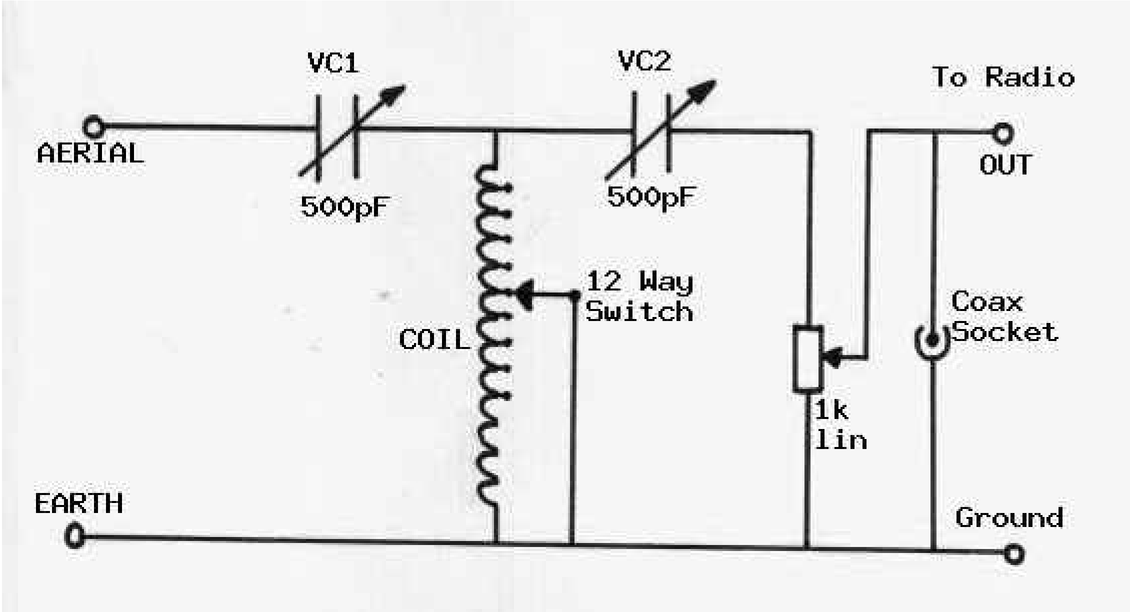
The circuit diagram below shows the circuit for a typical Pi type ATU which seems to be a popular arrange ment for many ATUs. I have built ATUs using this Pi arrangement and although they work quite well and are certainly a useful improvement over no ATU at all, I have found in my own experience that the 'T' arrangement in the next circuit works even better, matching more easily over a wide range of frequencies and also seemingly offering improved filtering in my own circumstances.

Each aerial arrangement is different and you may find that this circuit performs best of all in your circumstances:



Pi type circuit - Very popular for many ATUs

Below is the circuit diagram for my preferred choice of a T type circuit which includes a variable attenuator and which could not be simpler to construct. This circuit, with the coil described, covers from 500kHz medium wave to 30MHz short wave. Tuning capacitor VC1 is adjusted to match the aerial side while tuning capacitor VC2 is adjusted to match the receiver side. This circuit is often referred to as a TRANSMATCH, particularly in the USA.



T type circuit, which I have found to be more effective than the Pi type at my listening post, possibly because this design acts as a 'high pass' filter, and is therefore very useful for filtering out interference to short wave reception caused by high power medium wave transmitters that can overload the short wave radio

All that is needed is:

1	Self wound coil with 12 tapping points. See below
1	Reel of 22 s.w.g enamelled copper wire for coil
1	Coil former, eg the inside of a fax roll (30 mm diam approx)
1	12 way switch to select tapping pints on coil
2	500pF tuning capacitors (200pF or 365pF can also be used)
1	1 k ohm linear potentiometer for attenuator
2	Red terminal posts
2	Green terminal posts
1	Coaxial socket, e.g. 3.5mm jack (as used here) or SO239
1	Case 150 x 100 x 60 mm + with rubber feet

See additional notes below >

SOURCES FOR TUNING CAPACITORS

Old broken radio sets - but don't smash a nice one up for the sake of a capacitor! Old radio sets, especially the old 'valved' wirelesses are very interesting and often sound superb and could be quite rare.

J BIRKETT RADIO COMPONENTS,. 25 THE STRAIT, LINCOLN, LN2 1JD. telephone (uk) 01522 520767 http://www.zyra.org.uk/birkett.htm

MAINLINE GROUP http://www.mainlinegroup.co.uk/jacksonbrothers/index.htm

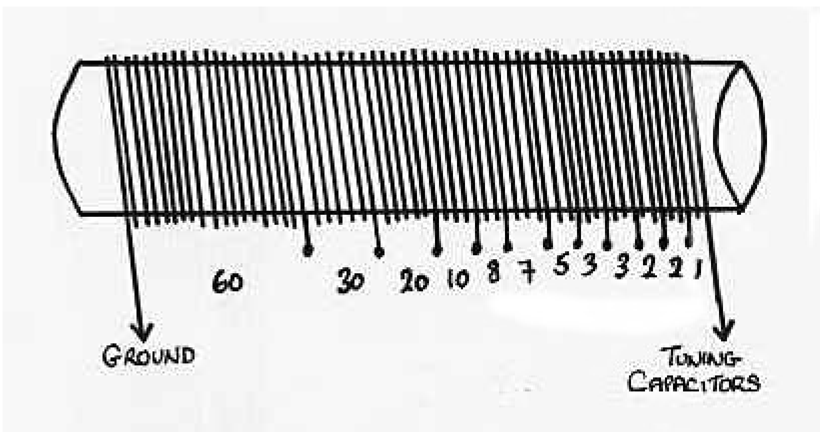
COIL WINDING DETAILS

The coils that I have made for my ATUs have been wound around formers made from the plasic tube found inside a typical fax roll. This can be cut to a suitable length to fit inside the enclosure, in this case 150mm long with a 30mm diameter. If a plastic fax roll is not available then a strong cardboard tube could be used instead.

Two small holes can be drilled at each end of the tube to feed the start and finish portions of the 22 swg wire through in order to secure it. Then wind the required number of turns, putting a tight twist in the wire at each tapping point, taking care to scrape off the enamel so that the connecting wire can be soldered into place.

Alternatively, as I did in my first coil, I inserted printed circuit board (PCB) terminal pins into the tube to secure the wire to at the start and finish points of the coil and at each tapping point, as you can see in the photograph below. This involved drilling a hole in the soft plasic of the tube slightly smaller than the PCB pin and forcing the first pin in for a tight fit. The enamel must be scraped of the wire, wrapped arount the pin with a single turn and then soldered in place - quickly to avoid melting the plastc! Then the first turn of the coil is made, another hole drilled and pin inserted and wire scraped clean of enamel and soldered to the pin. Proceed until all the turns and tapping points have been made according to the diagram.

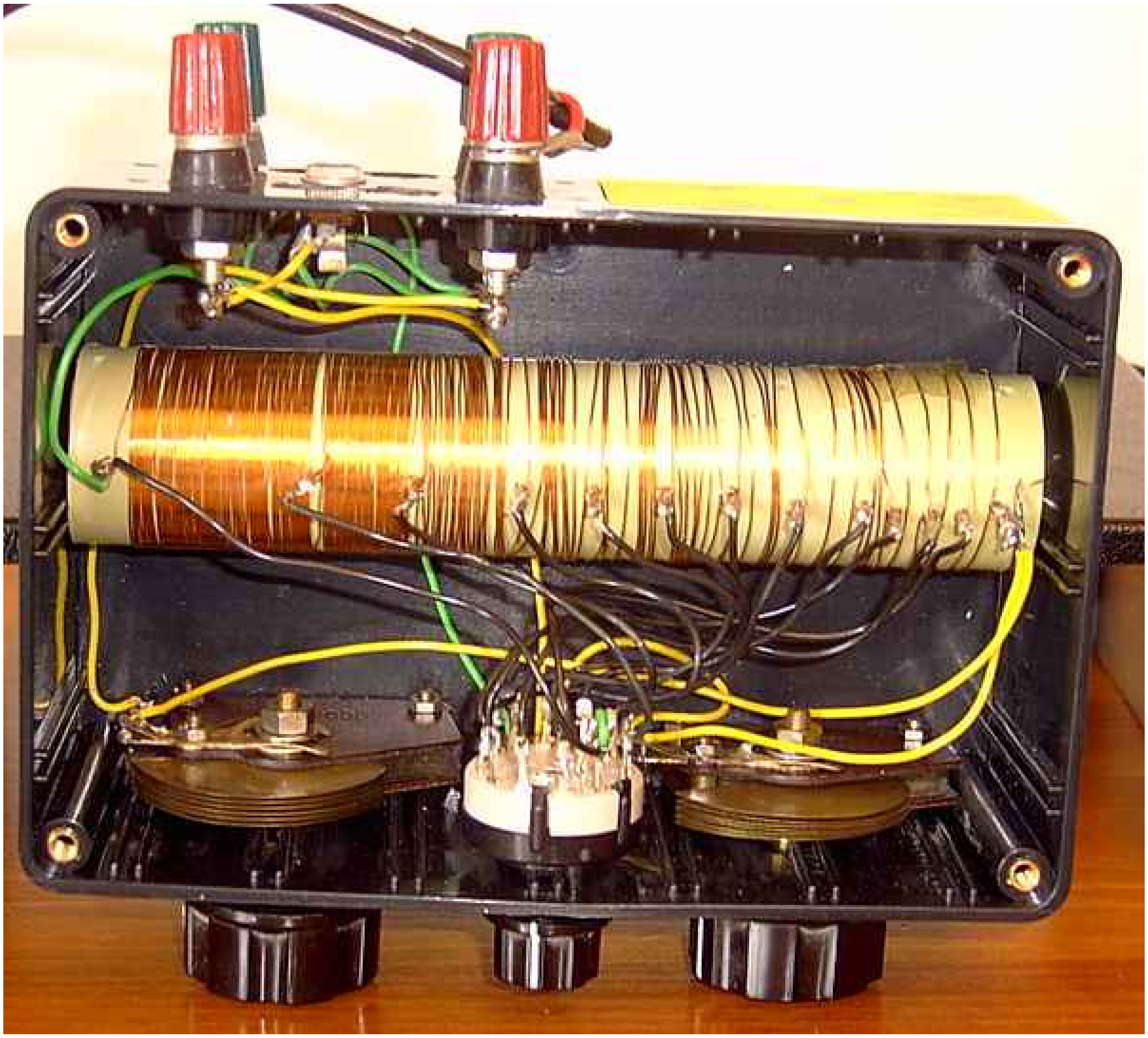
The diagram below shows the number of turns between each tapping point:



Once the coil is complete the tapping points can be wired to the 12 way switch by using short lengths of hook-up wire (e.g. 7/0.2mm pvc covered), being careful to wire the into the circuit exactly as in the diagram.

The Mk1 ATU using the T type circuit

The rear panel of the Mk1 ATU showing the aerial input and output terminal posts.
A 3.5mm jack socket is also included as an alternative output socket for convenient connection to a portable radio via a length of flexible 50 ohm coaxial cable



Internal view of the Mk 1 Antenna Tuning Unit showing the coil and its 12 tapping points, the range switch and two space-saving Jackson type solid dielectric tuning capacitors. The potentiometer that forms the variable attenuator is hidden from view by the range switch.

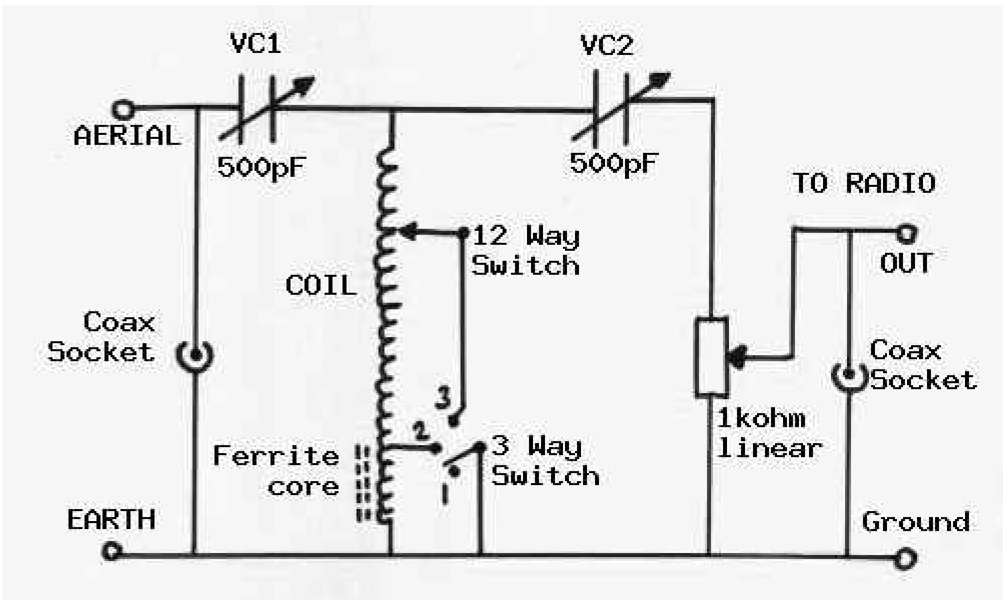
The Mark 2 Aerial Tuning Unit

The Mark 2 Antenna Tuning Unit

The Mark 1 ATU described above was initially made using the Pi match circuit and when I made this, the Mark2, I used the T match circuit design and when I found that it worked even better I modified the Mark 1 to also use the T match circuit layout.

The Mark 1 is used for a portable radio and therefore is more compact, the Mark 2 is used for the HF-150 so can be a bit larger. It is housed in an aluminium case and uses the larger air-spaced tuning capacitors and also has SO239 sockets are fitted for the input and output.

The coil is larger too, using the same former made from the centre of a fax roll but longer at 220mm to accommodate additional windings to enable coverage of long wave frequencies. An additional switch is also included to give plenty of adjustment while including the long wave range.



The circuit diagram showing the coil and the 12 way switch to adjust the Short Wave ranges and the additional 3 way switch to change to Medium Wave and Long Wave coverage*. The attenuator is simply a 1k ohm potentiometer.
* Position 1 is Long Wave; 2 Medium Wave; 3 Short Wave ranges - adjusted with 12 way switch

<u>Tuning Capacitors</u>: In these circuits, as is the general rule of thumb with radio projects, the moving vanes of tuning capacitors - and therefore the spindles/shafts - are connected to the earthy side of the circuit. Ensuring that the moving vanes are connected to the earthy side minimises 'hand capacitance' effects when touching the adjustment knobs. The fixed vanes are therefore connected to the 'hot' (top) side of the circuit.

You will have to determine which terminals on your particular capacitor are connected to the fixed vanes and which are connected to the moving vanes. It should be able to determine this visually from the physical construction of your particular component, but if you are unsure always use the continuity tester function of your multimeter.

With dual gang variable capacitors with smaller values per gang, it may be desirable to connect the two fixed sets of vanes together in parallel to increase maximum capacitance. For many metal framed air-spaced variable capacitors the moving vanes will effectively be connected together via the brass spindle to the main frame of the capacitor body. The fixed vanes and their associated terminals will be isolated from the metal frame by ceramic,

paxolin, or similar, insulators.

PARTS REQUIRED

1	Self wound coil with 13 tapping points
1	Reel of 22 swg enamelled copper wire
1	Reel of 30 swg enamelled copper wire (for longwave part)
1	Coil Former **220mm** long & approx **30mm** diameter
1	12 way switch
1	3 way switch
2	500pF tuning capacitors (200pF or 365pF can also be used)
1	1 k ohm linear potentiometer
2	Red Terminal posts
2	Green terminal posts
2	SO239 sockets
1	Aluminium case 220 x 130 x 65 mm + rubber feet

See additional notes below >

SOURCES FOR TUNING CAPACITORS

Old broken radio sets - but don't smash a nice one up for the sake of a capacitor! Old radio sets, especially the old 'valved' wirelesses are very interesting and often sound superb and could be quite rare.

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MAINLINE GROUP http://www.mainlinegroup.co.uk/jacksonbrothers/index.htm]

COIL WINDING DETAILS

The coil is essentially the same as the coil described above being wound on the centre of a fax roll or any similar former approximately 30mm in diameter, but slightly longer at 220 mm long. In this case I secured the start and the finish of the windings by simply looping the 22 swg enamelled copper wire through two small holes at each ends of the former to secure it in place. The taps are formed by simply twisting the wire into a loop at each specified interval, to form the connection points to the range switch, making sure that all the enamel is scaped off so that the connecting wires to the switches can be properly soldered in place.

One difference with this coil is that it is designed to cover the Long Wave band too, and the final 110 turns are wound from slightly thinner 30 swg enamelled copper wire, this was done simply to save space. Inside the tube at this end are placed a couple of short lengths of ferrite rod, no longer than 50mm. These are then adjusted, once the ATU is functioning, to give the required tuning range. Alternatively more windings could be added to the final winding to increase its inductance until the desired range is achieved.

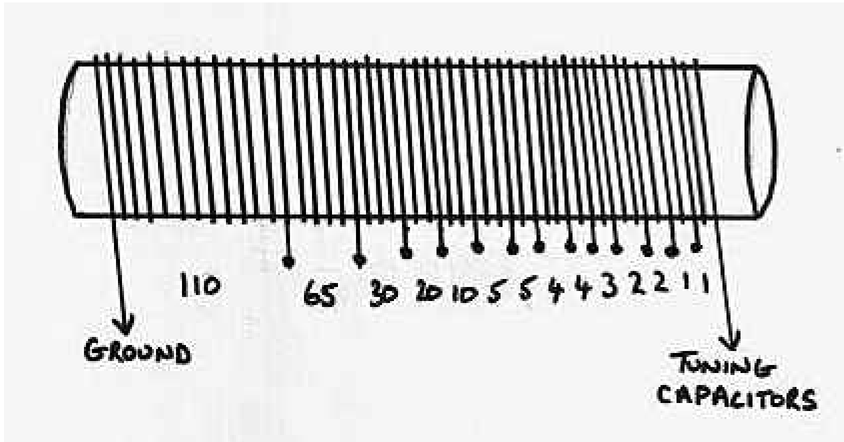
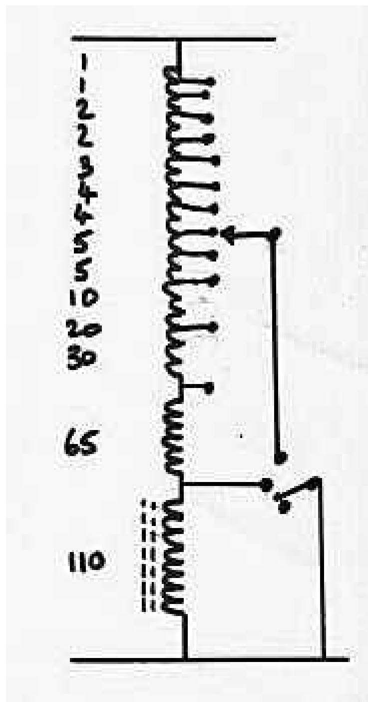


Diagram showing the number of turns between each tapping point



Detail of tapping point intervals and how the coil is wired into the circuit

Detail of tapping point intervals and how the coil is wired into the circuit

The rear panel. On the left the input terminal posts for the aerial and earth wires, with the addition of a SO239 socket for the connection of coaxial cable. On the right the SO239 coaxial output socket for connection to a radio with a coaxial input socket also provided are the alternative terminal posts for single wire output and ground connections to the radio.

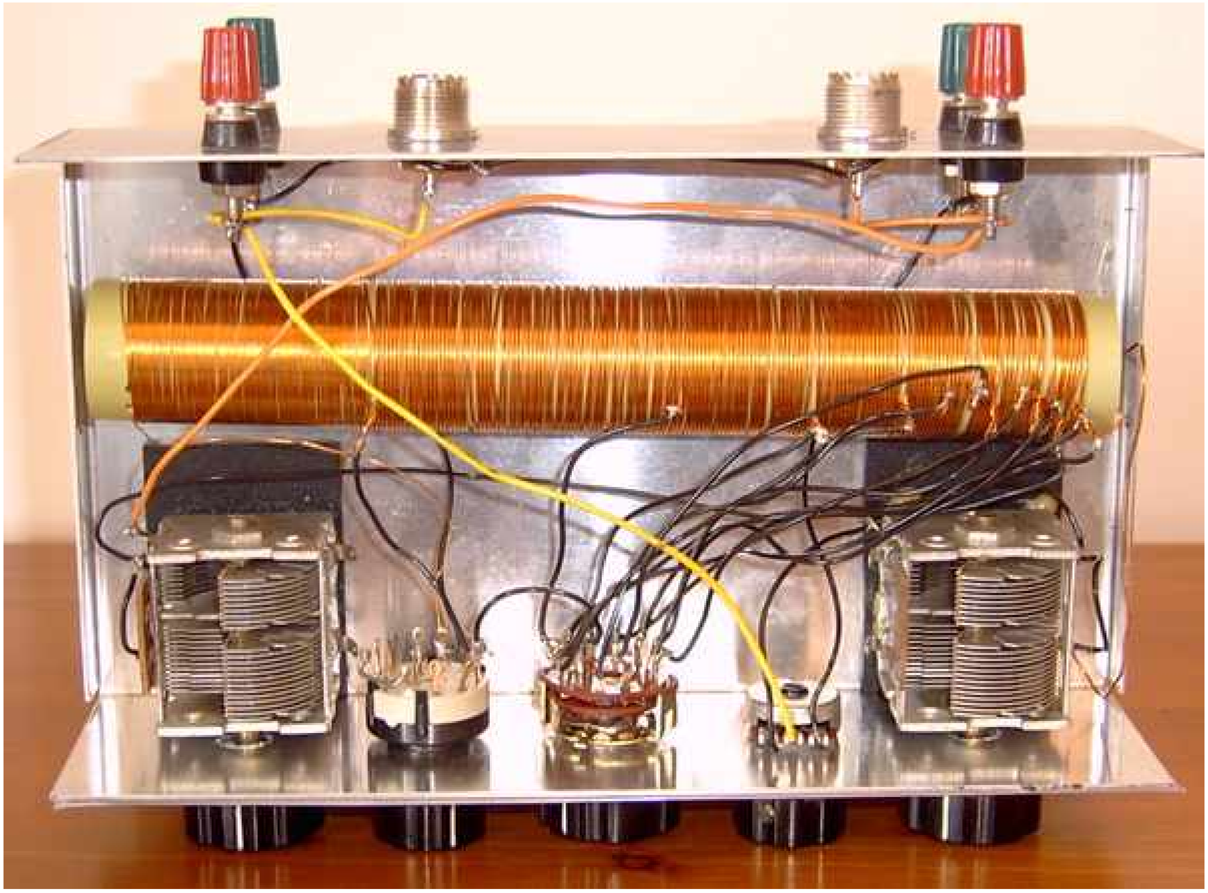


Photo showing the relatively straightforward internal construction of an ATU.
2 large air-spaced tuning capacitors, range switches, potentiometer, and coil with 14 tapping points.

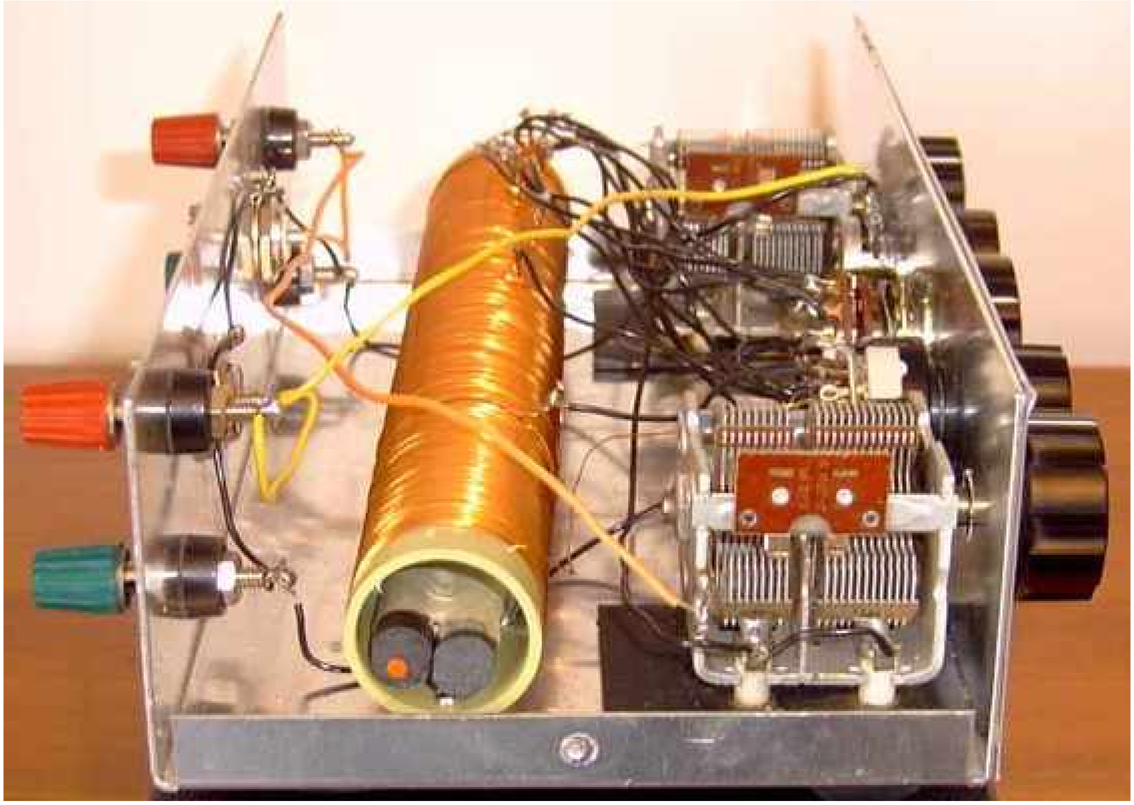


Photo showing how two 2 inch lengths of ferrite rod are put inside the coil at the longwave end of the coil to provide coverage of these low frequencies

ADDITIONAL NOTES:

Thank you to Dr Paul S Crawford who e-mailed us with this additional useful advice:

"You have basically have a capacitor input system connected to the antenna, my own preferance is always to put a 100K Ohm 'bleeder' resistor to GND on such an input just to stop any static build up on hot dry days, etc. Of course, you might also want to include a neon lamp across the input as a crude (but cheap) induced lightening surge arrestor as well.

**Regards,
Paul "**

Thanks Paul for taking the trouble to get in touch. The lightning arrestor is certainly an excellent safety feature, and if you are troubled with noise caused by a build up of static on the aerial wire, then the 100k resistor is a good tip.

A Question About The Daiwa CL-22 antenna coupler

Dear Sir, I hope you can answer a few questions for me, if you can help me, it will be gratefully appreciated, firstly i am 11 years old, and have just started SWL listening with a DX 394 radio, been using a end fed long wire about 25m long into back of radio.

*Recently bought a Daiwa cl-22 coupler(atu) at a car boot sale for £3, it looks in mint condition, but didn't come with any operating instructions, and scoured the internet for some with no effect.
the ATU, has 3 controls on the front..... one marked Receiver, one marked Antenna, both theses are variable controls, and one marked band (A to G), i understand the Band control, also the Antenna control, what is mystifying me, is the variable control marked Receiver ?.*

Also on the rear of ATU is 4 screw terminals, grouped in pairs, one marked Receiver, and the other marked Antenna, the Antenna screw terminals are coloured ,one black and one red, and the same for the Receiver terminals, they are very small screw terminals, looks like they only for very thin wire, my question is how do i connect my long wire to the ATU, and to which terminal?

I really hope you can help me with this, as your web site seems to be the only one, on the internet, which seems to want to help anyone like myself, looking forward to hearing your reply.

Thanking you, Ashley Griffiths. May 2012

Hi Ashley, I am not familiar with this particular unit, but most antenna matching units are similar in operation. One pair of terminals on the rear will be used to connect to the antenna and the other pair to the receiver.

Use RG58 coaxial cable to connect between the a.m.u. and receiver. The red to the centre conductor of the RG58 coaxial cable and the other terminal to the outer shield. Some antennas use coaxial cable to feed to the receiver or a.m.u., but in your case you are using a single random wire as an aerial, so simply connect this to the red terminal.

Often connecting the other (ground / GND) terminal to an earth / grounding stake driven in to soft damp soil outside can help reception. Possibly reducing interference or increasing signal strength. It's worth trying, but it does not always help in every case. I don't know without seeing the physical circuit what the actual circuit topography will be. It could be what is known as a "T" match or perhaps a
"Pi" match. Nevertheless the controls on your a.m.u. will perform the same functions and will likely be as described below.

All three controls will tend to interact with each other. The band control is most likely to be a multi-way switch that selects tapping points on an inductor (coil). This sets the general band of operation - usually from around 3MHz at the longer wavelength end of the short wave (H.F.) bands up to around 30MHz at the shortest wavelengths of the short wave (H.F.) band.

'A' will correspond to one end of the HF band (maybe the shortest wave / highest frequency end) and 'G' the other end (maybe the longest wave / lowest frequency end) - or the other way around. You will determine this by experimentation. The other two controls will normally be variable capacitors. One of these will be on the antenna side of the circuit, while the other will be in the output (receiver) side of the matching circuit.

All the controls have to be adjusted to provide the best impedance match between the receiver which always requires a 50 Ohm antenna impedance and the antenna which will present a complex and varying impedance of just several ohms to (perhaps) many hundreds of Ohms dependent on frequency being used.

For example if you want to listen to a radio station in the 31 metre band and your particular random wire antenna presents 50 Ohms to the receiver's antenna input socket then conditions are well matched and you will not need to use the matching unit, indeed it may have little or no effect and may even induces losses that actually weaken reception!

However if on the 31 metre band your random wire antenna presents an impedance (resistance to an alternating current) of several hundred Ohms or more, or a lot less than 50 Ohms then matching will be poor and some of the signal will be lost. This is when the matching unit can help. By adjusting the controls correctly better impedance matching can be achieved so that more of the

signal is ransferred from the random antenna to the radio receiver.

Each band will be different and will need different amounts of matching. You will need to experiment with the controls and determine the best position of all three that produces the highest signal strength. Make a note of their positions for each HF band on a paper chart so that you can easily and quickly set the correct positions in the future as you hop from band to band on the receiver.

I think that's as much as I can tell you without knowing or seeing the actual a.m.u., but these basic principles are the same for any a.m.u. - I hope that helps!

73
Mike
M0MTJ

Hi Mike, Thanks for sharing your expertise and experience!

I am an American living in Mexico and want to use a longwire antenna of about 130 feet for shortwave listening. Am thinking to bring the signal into the house with a 9:1 unun and RG8x coax, then fine tune with your ATU MK II into my Yaesu FT-847.

I don't understand the use of the two ferrite rods.... do they simply enhance the effect of the wiring in the fax tube or do the rods have wires wound around them as well? For the alternative of more windings around the fax tube (I assume that eliminates the need for the rods), about how many more windings?

If I cant find a fax paper tube (30 mm = 1.1811 inches) can I use pvc plumbing pipe that is either 3/4 nominal =1.050 inch outer diameter or 1 inch nominal = 1.315 inch outer diameter?

I cant find 500 pf tuning capacitors so will use 365pf instead...do you know which frequencies I will not be able to tune as a result?

I understand the longwire is directional, pointing toward the far end. Will it likely cover at least 22.5 degrees to each side of its direction?

Is a plastic enclosure just as good as metal, or is shielding an issue? Your photo seems to be of a plastic box, and I can source a plastic enclosure locally.

I wish I could find people like you here where I live in Mexico to share ideas, and passion for whatever hobby it might be, SWL, amateur radio, and so forth.

My great grandparents are British but I haven't visited your country, but will someday. I am envious because you have so many enthusiasts for many interesting activities in your country. I even have the idea that all your countrymen have amazing gardens in their backyards...

When I know what to order so can start to collect the parts...

Thank you Mike, Ransom Peek in Patzcuaro, Michoacan Mexico. (November 2014)

Hi Ransom,

Thanks for your email, it's nice to hear from you.

Using a 'long wire' (I prefer to use the term 'random wire') antenna fed via a 9:1 UnUn is a popular antenna to use at present. It's certainly not the ideal antenna for all circumstances, but as a compromise 'all around' antenna it is probably a pretty good choice.

The two ferrite rods are plain - no additional windings. I simply used them to increase the inductance of that section of the coil windings, therefore allowing use on the lower frequency bands. Their size and position within the tube will dictate the actual frequency range of that section. So - nothing critical, but you may need to experiment a little.

The same applies to the tube. The size is not critical, but it will effect the inductance and hence the frequencies that are covered. Anything (card / paper / PVC) of about 25 to 30 mm (i.e. about 1 inch) will be fine - but again you may need to experiment with the final tapping positions to ensure that your obtain the frequency coverage that you require. I cannot give you absolutes - but the rule is; the larger the diameter of the coil the higher the inductance and hence the lower the frequency - similarly the greater the number of turns on the coil the higher the inductance and hence the lower the frequency - and obviously the converse is true.

365pF cap's are fine and are, in fact, commonly used in ATU's. Naturally the frequency coverage will be a bit different using smaller value cap's, but this can likely be compensated for by adjusting the tapping points if necessary. Lower value cap's may need a few more turns on the coil to compensate.

A straight wire will have some directionality, but depending on the frequency of operation, the pattern will tend to break up into lobes causing some nulls in certain directions. As a rule of thumb, however, the deepest nulls will tend to be off the ends of the wire, while the greatest signal pick up will broadside to the wire.

Please also note that this is a receiving ATU, it has not been rated for transmitting, although it might be ok QRP operation (i.e. < 5watts).

If you have not already done so - just try the 9:1 fed antenna straight into the radio. It may be fine for your swl needs as it is. Then, if you feel that you need a bit of impedance matching, you could try making the ATU. Of course - there can be endless experiments with antennas!

A plastic case should be fine for a receiving ATU.

It is interesting to learn that your great grandparents were from the UK!

As for back gardens here - well they can be of all shapes and sizes, or, indeed, non existent!

Our garden is quite small - but the gardens of many older (1930's) suburban houses could be 100 feet long, or much more. The back gardens of newer houses tend to be very compact - even for larger houses - due to the VERY high cost of land nowadays. Small gardens are called "Postage Stamp" gardens. Of course, many people live in flats and apartments, some of which have shared/communal gardens, and some have no gardens at all. The radio enthusiast therefore has to devise all sorts of compact or 'stealthy' methods of installing an antenna! Maybe a wire aerial supported on a fibreglass fishing pole fixed to the balcony, perhaps.

I hope that helps! Good luck with your projects.

73
Mike
M0MTJ

More about Components / Aerials / UnUns and Baluns

Simplification: If do not need cover the long wave or medium wave bands then you can omit those windings. This will make construction and wiring simpler.

Variable Capacitors: The variable capacitors can be anything over 200pF in value - just bear in mind that smaller values will not give as much adjustment range as larger values. Using a smaller value capacitor, such as 200pF, should not be a problem but it may require some experimentation with different tapping spacings, or perhaps using a greater number of tapping points, to obtain the required band coverage.

The use the miniature polyvaricon cap's which have a value of around 200pF will help keep costs low and will work perfectly well in receiving ATU's. You might also find these in old junk pocket transistor radios that can be salvaged for these sorts of projects.

Aerials and Feeder arrangements:

This will be a case of experimentation to find what provides the best reception - whether that be best signal strengths from stations of most interest, or lowest noise - i.e. best Signal to Noise ratio (S/N).

Try a 'long wire' aerial to begin with. Actually the expression 'Random Wire' is a more accurate and better terminology. Connect the aerial wire directly to the ATU. This may give good signal strengths but may also be noisy.

If you are troubled with noise:

Try connecting coaxial antenna cable to the ATU with shield to the ground terminal and centre conductor to input terminal. Take the coax to the outside the house and connect the the inner conductor to the random ('long') wire aerial. This may lower noise - or may just lower signal strength! It is important to attempt to judge whether the Signal to Noise ratio has improved. It might be found that actual strengths have been lowered, but that the noise level may have reduced by a greater extent, so as long as the signals are still resovable the overall noise should be lower.

Further experiments: Experiment with connecting the far end of the coax inner conductor to the random aerial wire but also connect the shield of the coax to an earth stake in the back yard or garden. This will change the aerial system - possibly reducing local noise pick up - possibly not!

Also experiment with a matching transformer at the far end of the coax. The use of an UNbalanced to UNbalanced transformer would be the most appropriate for this purpose - so try winding a simple 4:1 ratio UNUN or perhaps try a 9:1 UNUN which may work even better.

There are numerous UNUN designs on the web often using a toroid core, while some designs also use a 10mm ferrite rod. The wire used to make the windings might be enamelled copper wire or even p.v.c. covered wire. Either method would be good for these experiments. Here are some links for constructing UnUns and BalUns:

UnUn designs

M0UKD - 9:1 Unun (so-called magnetic longwire balun):
http://www.m0ukd.com/Magnetic_Long_Wire_UnUn/index.php

How To Build an UNUN by G7LRR:
http://www.pcsystems-ss.co.uk/g7lrrweb/index.php?module=pagemaster&PAGE_user_op=view_page&PAGE_id=52&MMN_position=77:37

IW7EHC - Unun Design for Longwire antennas:
http://iw7ehc.altervista.org/ununEN.htm

Balun designs

Build An Air Wound 1:1 Choke Balun For HF: http://www.hamuniverse.com/balun.html

1:1 Balun for balanced dipole aerials : http://www.m0ukd.com/1to1_HF_Balun_for_dipole/index.php
http://warga11mc.blogspot.com/2010/07/balun-11-14.html

Cost Effective 1:1 Current Mode Balun:
http://www.arising.com.au/people/Holland/Ralph/cmbalun.htm

Inexpensive 1:1 Balun: http://oz1jux.dk/balun.htm

Build a 1:1 Coaxial Balun: http://www.iw5edi.com/ham-radio/?a-1-1-coaxial-balun,41

Broadband Balun Design: http://www.qsl.net/ta1dx/amator/broadband_baluns.htm

Step-By-Step Construction of a 4:1 Current-Type (Guanella) Balun:
www.n0ss.net/qrp_4-1_guanella-type_balun.pdf

Making Baluns 1:1 and 4:1 Baluns - Swindon and District Amateur Radio Club:
http://www.sdarc.net/wp-content/uploads/pdfs/Making_Baluns.pdf

Air Wound 4:1 balun: http://www.combotec.com/projects/balun14/balun14.html

Home brew a 4:1 balun: http://www.rason.org/Projects/balun/balun.htm

4:1 balun for 160 to 10 meters by Clay Wynn: http://www.hard-core-dx.com/nordicdx/antenna/feed/4_1balun.html

4:1 and 1:1 Balun ideas by PD7BZ
http://www.pd7bz.com/radioprogs/manuals/balun_transformer.htm

Balun Winding: http://users.catchnet.com.au/~rjandusimports/balun_winding.html

4:1 and 1:1 Balun construction by M0SCG: http://www.m0scg.org.uk/Projects/?p=207

QRP 4:1 Balun for 160 to 10m : http://www.dxzone.com/cgi-bin/dir/jump2.cgi?ID=16753

UK Source for Silver Plated PTFE (Teflon) covered wire for winding higher power baluns:
http://wires.co.uk/acatalog/ptfe_covered.html
14awg / 16 swg or 0.16 mm dia wire. 12awg / 14swg 0.2mm dia wire and larger toroid for higher

powers.

Balun using T200-2 toroid (17 turns of e.c.w.) or T200A-2 toroid (13 turns of e.c.w.) for 400 watt H.F. Balun.
T400-2 Toroid (14 turns of e.c.w.) for 1000 watt H.F. Balun.
Amidon ferrite & powdered iron cores & ferrites: https://www.amidoncorp.com
Bytemark ferrite & powedered iron cores & ferrites: http://www.cwsbytemark.com
http://www.bytemark.com

I hope you enjoy building one of these useful devices, and enjoy even more the benefits that an ATU can bring to your listening post with minimal expense.

73
Mike
MØMTJ

Radio Stations & Memorabilia | **Loop & Frame Aerials** | **Copper Tube Antenna**

DXing & Short Wave | **Make A Signal Meter** | **Riding On A Radio Wave**

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ON6MU's "Vipormutant" Antenna
RE-AHFV14P

Versatile Inexpensive Portable Multi-band Tunable Antenna

de ON6MU
revision 2

Features

- Only 3 meters high fully extended (effective radiating element height)
- Less then one meter inserted (no element is larger then one meter including the tunable section)
- Tunable without the use of an extra tuner (just switch till you get the best SWR)
- Covers all frequencies from UHF to 7 MHz without a tuner
- UHF (tuned by de- or increasing the length of the antenna) 3/4 2*5/8 4*5/8
- VHF (tuned by de- or increasing the length of the antenna) 1/4 5/8 2*5/8
- HF (tuned by switching)
  6 meters (1/4 1/2)
  10 meters (1/4)
  12 meters
  15 meters

17 meters
20 meters
30 meters
40 meters: with large counterpoise and/or with longer radiating element, or extra tuner
80 meters: if radiating element is > 5 meters, or with large counterpoise and/or with extra tuner

- Works with or without cointerpoise
- Ideal as portable or balcony antenna
- Compact and extremly portable
- Not too critical on the material or sizes of the elements
- +- 50 watt input
- SWL's Note: tunable on all frequencies between the bands mentioned above

What you need to build the "Vipormutant"

- 5 (or more depending on how high you want your boom) alu tubes
- piece of hard insulating tube (+- 7 cm), examples: plastic, nylon, bamboo...
- some low loss RG174 50 Ohm coax
- carbon/ferrite bead or toroid (to act as a choke)
- a few meters of 0,75mm enamelled copper wire to make the coil
- SO239 (PL259 female)
- Paint, silicon, glue etc. to seal things up
- Plastic box to mount over the coil and where we'll put the switch and SO239 connector
- 12 position rotary switch
- a few innox hose clamps

About the "Vipormutant" antenna:

Well yes, one must have a name HI...It is nothing more then a base coil loaded antenna, but with a selector direct on the base to tune the antenna.
Most of us don't have the luxury of building a 1/4, 1/2 or even a 5/8 wavelength vertical antenna for HF. We have to settle for something a little shorter. (A lot shorter, in the case of people following the FCC's Part 15 rules, which limit them to 3 meters in size.) Shorter vertical antennas can give acceptable (but not spectacular) performance.
I needed a highly (HF) portable antenna to use with my FT-817 which should have the highest possible frequency range (also VHF) and still compact enough to take along almost anywhere! The antenna should be versatile enough to allow further experimenting, to allow being mounted on a balcony, caravan, outdoors etc... So I came up with a compact vertical (dismounted no higher then 1 meter) with a "tuner" directly connected to the antenna radiating element (the best possible place a tuner can be).
The "Vipormutant" tuning principle gets energy into the antenna on a wide range of frequencies, but the design of an antenna is what controls what happens to the RF energy from there. For some antennas, the antenna is simply not complete without a radial system, or at least a counterpoise. Other types of antennas need no RF ground system at all. Most reference books on antennas provide solid guidance on radials and counterpoises, but only for antennas cut to a specific frequency. When using the "Vipormutant" it will also act like tuner and at the best place a tuner should be: directly beneeth the antenna! So the rules have to change somewhat because the "Vipormutant" almost operates across the full range of HF frequencies unto UHF. It doesn't need a counterpoise to work, but the efficiency will increase when you do use it.

Considerations:

- If the length of the conductor is very short compared to a wavelength (< wave/4), the electric and magnetic fields will decrease dramatically within a distance of one or two wavelengths.
- It is impossible to make a small antenna to radiate as efficient like a big antenna.
- Ground losses affect radiation patterns and cause high signal losses for some frequencies. Such losses can be greatly reduced if a good conducting ground is provided in the vicinity of the antenna.

The coil/tuner

Wind 0,8mm enamelled copper wire around the isolator (+- 16mm diamter) and make a tap every xx turns (see fig. 2 and 3)

Fig.1

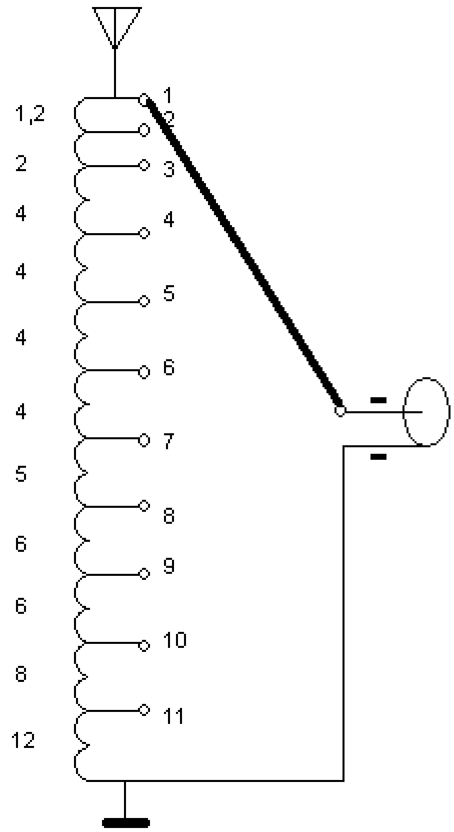


Fig.2  The coil dimensions isn't too critical.

Relatively short antennas behave like lossy capacitors and present a high impedance load to the transmitter due to the large amount of capacitive reactance that is present. The loading coil helps to tune out that reactance. Tuning out the reactance is important because a tuned antenna will accept and radiate much more power than a mismatched antenna.

When the loading coil is installed at the bottom of the vertical radiator, we call it a "base loaded" antenna. Base loading requires the smallest amount of inductance to achieve resonance.

The shoke

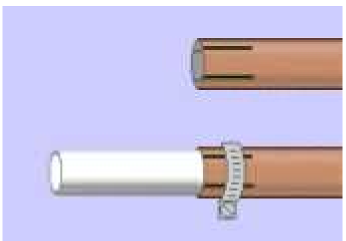
Is made out of miniature 50 Ohm coax (rg174) that goes a few turns through the carbon/ferrite bead or toroid. You can also use a Snap-Together Ferrite Choke Core.
If a ferrite is put over a cable which includes both signal and return lines, it will have no effect on the signal (differential-mode) current but it will increase the impedance to common-mode currents. This is because the differential currents, by definition, sum to zero in each wire pair and therefore there is no net magnetic field. If there is no field, the ferrite is invisible. But the common mode currents do produce a net magnetic flux and this flux is concentrated in the bulk of the ferrite, leading to an increased impedance for these currents only. The choke should prevent any mantle currents flowing and should decrease RFI.

The effectiveness can be increased by looping the cable several times through the core, but the benefit is limited at higher frequencies by the stray capacitance between the turns of the cable.

Fig 3.

4 turns

The base insulator

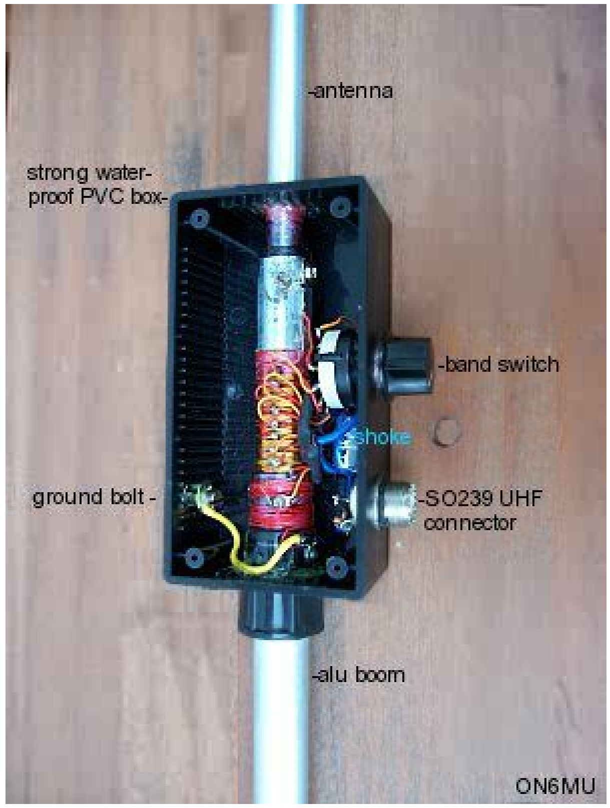


The vertical radiator "driver" element and tuning box

I used a plastic box of 130x70x40mm. On top and bottom I drilled a hole to fit the driver element (radiator of +/- 40cm length)and boom (also +/- 40cm length).
On the side I drilled a hole for the rotary switch and the SO239 connector, whilest on the opposite side I drilled a hole to fit a "ground" bolt where I can easily connect the counterpoise and/or ground to if needed.

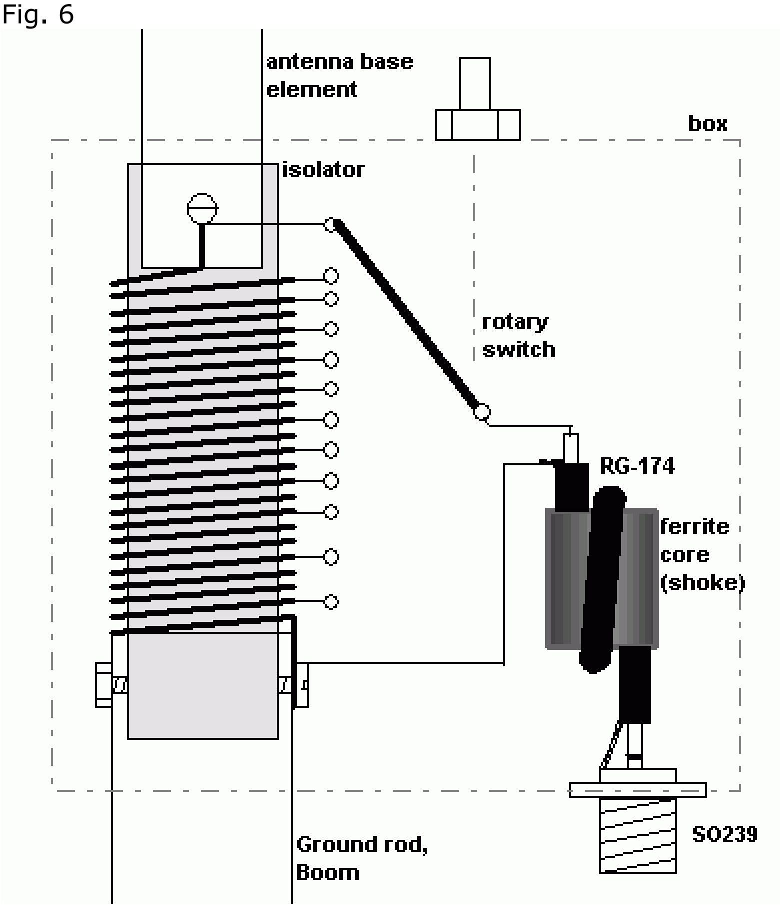
Fig 4

Fig 5



This is how things are connected inside the box:

Fig. 6



Example

The rotary switch is used for tuning the antenna on each band. The first position allows UHF/VHF ranges.
Tuning is done by sliding in/out of the elements.
The "lower" the switch (higher inductance) the lower the resonance frequency of the antenna.

Remember, and this is important too, to seal everything up so no moisture can penetrate the antenna! Because the radiating vertical antenna elements are made out of separate pieces that fits inside each other and are tightened by hose clamps, the construction isn't waterproof.
If you use a hollow isolating piece you need to to prevent moisture from getting inside the box (via the places where the elements are hold together). I've used a rubber "stopper" that fits snugly on the bottom of the driver element and glued tight.

Black paint finishes the job:

fig. 7

using a round box

In my first design I used a plastic box of 50mm diameter and 9 cm heigh. On top I drilled two holes: one for the driver element (radiator of 40cm) and a hole for the rotary switch (as was used in the first prototype).

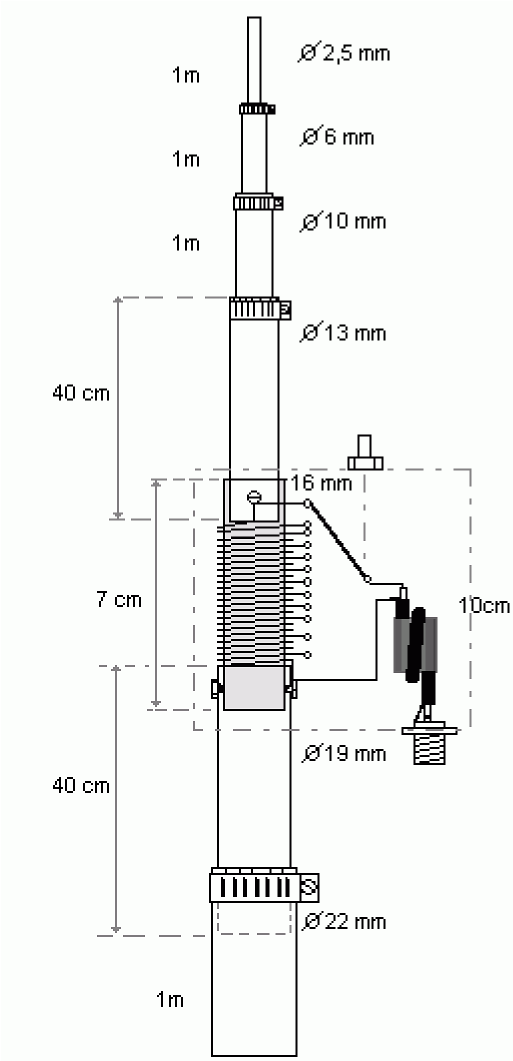
fig.8: The main driver element and tuning unit finished

This allows it to be used on almost any boom or can be extended to use with or without vertical elements! Ideal for experimenting!

Featuring Today

The antenna construction specs

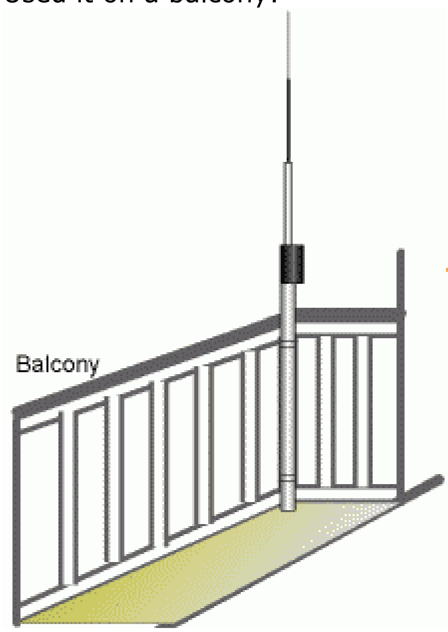
All elements are made out of aluminum.
Fig. 9

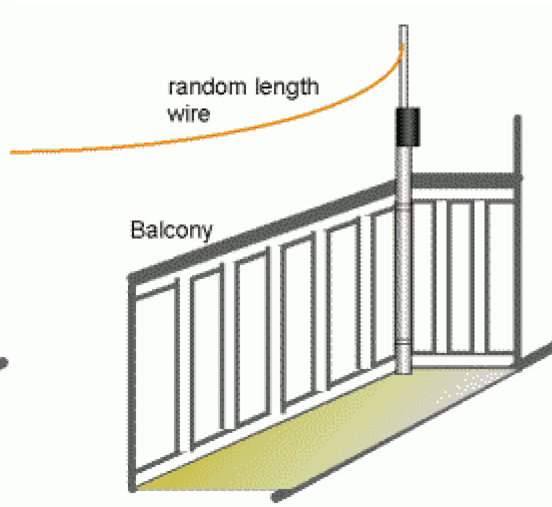


This makes the antenna effective radiating elements a total length of 3 meters. The boom elements can be chosen freely and on your needs. A short one (one element of a meter), a medium sized one of several 1 meter tubes or none at all! The bottom piece where the boom is "connected" too is 40 cm and can/could be put directly in the ground (if made pointed for sure). Or you could fix it in a umbrella stand. Use your imagination HI.

Examples of "Vipormutant's" utilization

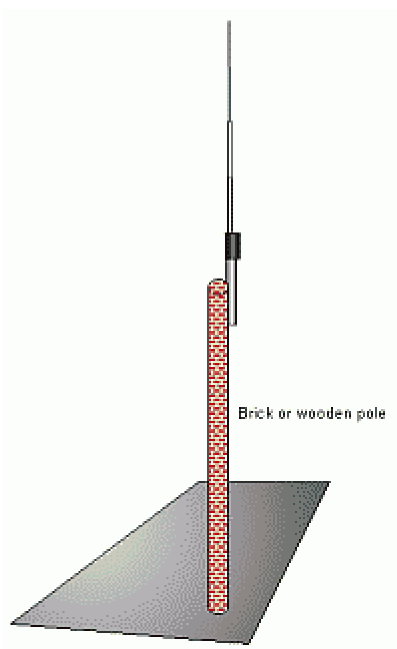
Used it on a balcony:

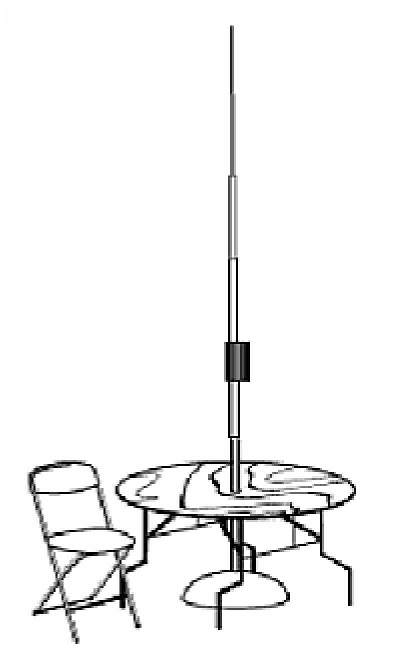




This could cover even the lowest HF-bands!

Use it outdoors without grounding:

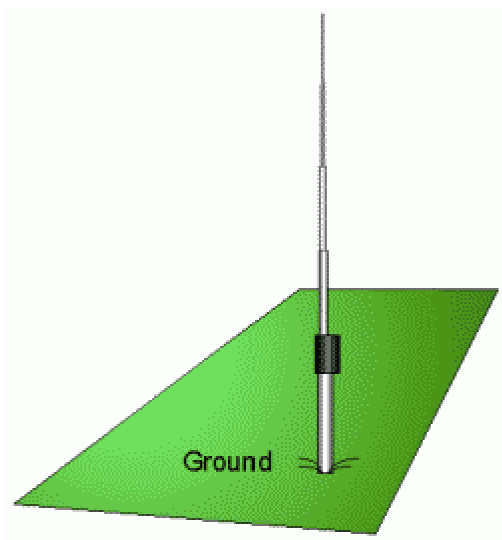


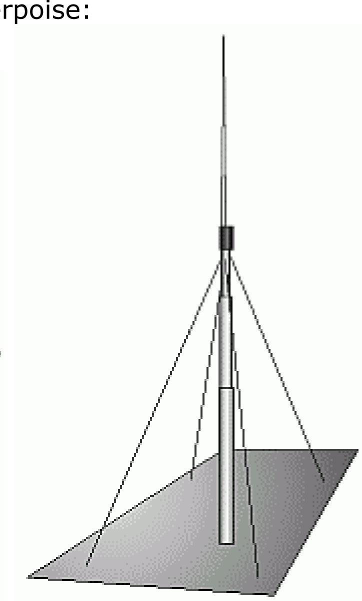


Use it outdoors as a shortened "dipole" balanced antenna (rotary switch set approx. in the middle):

Frequencies below 7 MHz could easily be match 1:1 SWR if total length of the "dipole" > 4 meters
Further tuning can be done with selecting a different impedance using the rotary switch.
Different lengths of wire can be used (an example: one part 3 meter, the other 5 meter or more)

Use it outdoors with ground or counterpoise:





Radials and Counterpoises basic purposes:

1. To improve the RF ground conductivity for the ground current return path. Unless you live in a salt-water swamp, your ground conductivity makes a very poor path for the return of ground currents. This increases the ground losses and reduces the efficiency of an antenna that needs a good RF ground.

2. To provide a counterbalance for the feed point of the antenna to reduce RF radiation back to the radio room. The "Vipormutant" changes the rules because there is no single frequency that you will be operating on, so all of the thumb rules for 1/4 and 1/2 wavelength radials don’t apply. It is possible to be either a purist or a pragmatist in deciding what radials to put in place.

3. Number of radials: More is better, up to a point. In carefully controlled experiments, it has been proved that increasing the number of radials from 2 to 15, or from 4 to 16, produces significant increases in signal strength. Further increasing the number of radials to 60 only produces 1 to 2 dB of increase in field strength. Follow this link to see some of the empirical data.

4. Where to put the radials: For a semi-permanent installation, it is customary to bury the radials a few inches down in the soil. This makes it much easier to mow and walk in the area around the antenna. However, some experimenters have gotten an improvement in performance by raising the radials and the antenna base a few inches above the soil. Raising the antenna and ground system several meters above the earth, for example by installing the base of the antenna on a roof-top, can improve the antenna's performance by reducing capacitive earth losses.

While the "Vipormutant" will provide a good match with a poor RF ground system which will will able you to transmit, your antenna efficiency will be low. Nevertheless, by using a tuning circuit directly at the antenna

radiating element losses are kept to a miminum. Getting the greatest efficiency out of your antenna system needs a proper RF ground unless you’re using a balanced antenna system

The efficiency of the antenna increases by using a counterpoise. However, the antenna can be tuned perfectly without!

Don't forget to check these out:

ON6MU Homebrew projects
Radioamateur related projects

ON6MU Ham mods
Modifications of transceivers

73"

Have fun and my best 73"

Guy, ON6MU
http://www.qsl.net/on6mu

Comments, pictures or experiences with my antenna are always welcome!

ON6MU

A POOR MAN's ANTENNA ANALYSER

(With sincere thanks to that outstanding engineer/designer, Jim Tregellas VK5JST [1], whose original work inspired me, for his patience, advice, understanding, tolerance and good humour in answering my many e-mails instead of telling me where to go!)

PART 1

With being a "canny Scot" (not to mention an O.A.P radio amateur), perhaps comes a certain increased motivation to look for cheaper, which in turn generally means simpler, solutions to problems which continue to confront me in this life-long, yet still stimulating hobby of ours.

I am in no doubt that in my early radio amateur days, and as a result of the lack of proper measuring equipment, mostly limited to a home-brew multimeter and a G.D.O. (grid-dip oscillator – blame Lee de Forrest for the "grid"!), I must have spent – sorry, *wasted* - hundreds of hours and miles of copper wire, in numerous early attempts at making the perfect antenna and any associated loading coils or traps. The G.D.O usually gave me more dips than the "big dipper" and I mostly had little idea what they *really* indicated.

Many moons later, along came the now almost ubiquitous "antenna analyser", in particular the MFJ-259. It seemed too good to be true – a possible solution to most of my problems…except one, I couldn't really justify spending £200 or more on one little black box. Luck was at hand however, on a visit to my old pal Bob Hope (the late LA2UA/5Z4LW) in Stavanger. Bob had won an MFJ-259 in a raffle, could see no need for it and would I like it (for past services rendered!)? I didn't have to be asked twice.

The completed "Mk4" antenna analyser

My world changed. Suddenly, guessing went out of the window, and I could accurately measure a host of previously semi-mysterious variables, and design and analyse the performance of antennas, especially portable and/or mobile. I was truly hooked and some years later, when the opportunity arose to buy the later "259-B" version for £100 new in the U.S.A. arose, how could I resist?!

But, and despite the virtues of these analysers, they remain beyond the pocket of many. I asked myself many times why this was so. Maybe the "canny Scot" in me makes me more curious/inquisitive. What makes them "tick"? Well, a typical analyser consists of an oscillator feeding a Wheatstone-type bridge, a frequency-counter and of course the aerial. The oscillator needs to be sinusoidal, wide-band, constant amplitude, stable and be able to deliver some power to the aerial under test – a tough specification! Various bridge voltages are interpreted to produce readings of aerial input impedance and S.W.R.

Despite the tough spec'. I asked myself if such an instrument could be home-brewed at much less cost. Having, in my teaching days, successfully built many simple frequency counters, that didn't seem a problem. The oscillator was a different story. Like many RAOTA members, my first transmitter was home-brewed. At the time (in the 60s), I built every conceivable valve oscillator (Colpitts, Hartly, Clapp, Pierce, Franklin, Tesla etc.etc) in the search for the elusive one which could be dropped from a foot above the bench, which had zero thermal drift, was unaffected by loading and produced a pure tone…I believe I got as close as was humanly possible on a near-zero budget and with limited East-African resources!

Fortunately, I now have a reasonably well-stocked junk-box. The first step was to design an ultra-simple but accurate 4-digit frequency counter around the now almost obsolete 74C925 counter chip I had saved from my long-gone days as a physics/basic electronics teacher. This worked to perfection. Then the problems began – the *oscillator*. This had to be stable, both in terms of frequency and amplitude, as well as sinusoidal (i.e. harmonic free), ideally from below 1.8MHz to at least 30MHz, as well as being capable of supplying some power to a low-impedance load. My '60s solutions were useless….
At about that time, I had an e-mail from Patrick GW1SXN mentioning that Jim VK5JST had designed an MFJ 259B-type antenna analyser around a very stable, constant amplitude, wide-band "power" oscillator and a multi-function LCD display, the whole lot being controlled by a P.I.C. chip. It was (and still is, I believe) available to Australian amateurs (and indeed anyone anywhere) in kit-form and at the then incredibly low price of *less than £40*! In true amateur fashion, Jim had also made the circuit and an excellent description, freely available on the internet (2).
Despite an intrinsic fear of P.I.C. chips (based wholly on my ignorance thereof), the Scot in me surfaced again, with the reasoning that if an Aussie could do it for £40, maybe (by cutting a few corners!), a Scot could do it for under £20! The target was set. Right away, I decided to omit the PIC chip…my analyser would not be able to compute reactance or impedance. However, I was more concerned with SWR and impedance at *resonance*.

The oscillator problem would be solved by (reluctantly) "copying" that part of Jim's circuit. After much staring at the circuit and head scratching, I finally felt I understood roughly how it worked. More problems arose…Jim used a double sided P.C.B (one side acting as a ground-plane) and transistors which I could not find here in the U.K. After much pouring through transistor data, I plumped for what I considered to be a near-equivalent, readily available and costing a few pence each. I could have ordered the P.C.B. from Jim, but this was "cheating" going a bit far! I opted (to Jim's total amazement and, more especially, horror) for my much-practised, miniaturised Veroboard techniques. After many months of utter frustration (spread over two winters), but driven on by stubbornness and a determination to make it work against all the odds, I finally succeeded…not quite perfectly…I had to add an output FET buffer stage…Jim later reckoned my chosen transistors, despite seeming to be near-identical, were in fact "marginal"…I would now agree!!
I now had the necessary low output-impedance power oscillator with which to feed a fairly traditional Wheatstone bridge circuit. A few diodes and some op-amps completed the set-up. All that was left to do was to produce a new meter scale, to show aerial resistance (at resonance) and S.W.R. A quick check of my miscellaneous aerials showed that my analyser was in indeed not only capable of producing the same basic results as the MFJ-259, but at a fraction of the cost. I had in fact reached my target of "less than £20". Admittedly, I did have most of the components in my junk box, but I believe the target figure would have been achieved (or very close to it) had I had to buy all or most of the components.

Sad to say, having reached my goal, the instrument (as with many other completed "challenges)" now adorns a shelf in the shack. But, in a way, that's not the end of the story…rather the beginning of another.

PART 2

Forever seeking a challenge, I asked myself just what minimum "feed-back" the average amateur *really* needs, to ensure his/her aerial, commercial or home-brew, will work with the maximum efficiency theoretically possible for that particular design. I am also constantly aware that aerials are the one field in our hobby where it is still possible to experiment and meet the "raison d'etre" of our licence [as stated in the introduction thereto – Para.1, sub para. 1(1)(a)], and ultimately where considerable savings can indeed be made.

First of all, I observed that the majority of us work with *resonant* aerials. This means that the input impedance of the aerial, whilst perhaps not the ideal 50 ohms, *is* purely *resistive*, i.e. the reactance X is zero, hence the input impedance Z is simply R. Secondly, none of us needs a sophisticated oscillator of the type described earlier – we already have an even better one…in our rigs. Indeed, what are rigs but high quality, stable, wide-band, relatively powerful oscillators?! Furthermore, and for the same reason, we do not need a frequency counter. We *do* need an SWR-meter as this, together with a knowledge of R, will allow us to properly *match* the "R" of our aerial to the output impedance of our coax and our rigs (generally 50Ω). The remainder of this article describes a simple instrument which achieves all this, and perhaps best of all requires ***no power source*** other than a few watts of RF power from the TX!

Let us first of all look at how a typical "antenna analyser" works? The answer in some ways is "quite simply"…

Referring to **Fig.1**, the TX (suitably attenuated) produces an r.m.s. voltage **V** (typically 10V) across one diagonal of a conventional Wheatstone bridge (re-drawn in "rectangular" form for ease of interpretation) with 50Ω resistors in three of its arms, the unknown resistor $\mathbf{R_x}$ (the aerial) being placed in the remaining arm. This results in voltages $\mathbf{V_A}$ and $\mathbf{V_B}$ appearing at opposite ends of the other diagonal. As $\mathbf{R_1 = R_2 = R_3 = 50\Omega}$, $\mathbf{V_A}$ is **V/2**. $\mathbf{V_B}$ will depend on the relative values of $\mathbf{R_3}$ and the unknown load $\mathbf{R_x}$. $\mathbf{V_A}$ and $\mathbf{V_B}$ are then rectified by $\mathbf{D_1}$ and $\mathbf{D_2}$ respectively, producing d.c. voltages **√2** times the r.m.s. values. Diode $\mathbf{D_3}$ produces a third d.c. voltage representing the *difference* between $\mathbf{V_A}$ and $\mathbf{V_B}$. If we represent these three d.c. voltages by $\mathbf{v_1}$, $\mathbf{v_2}$ and $\mathbf{v_3}$ (and, for the time being, neglect diode forward voltage drops), we have:

$\mathbf{v_1 = \sqrt{2}V_A}$ $\mathbf{v_2 = \sqrt{2}V_B}$ and $\mathbf{v_3 = \sqrt{2}(V_B - V_A)}$

Let us now consider the following three basic bridge conditions:

(i) $\mathbf{R_x = 0}$ (ii) $\mathbf{R_x}$ **= 50 ohms** (iii) $\mathbf{R_x} = \infty$

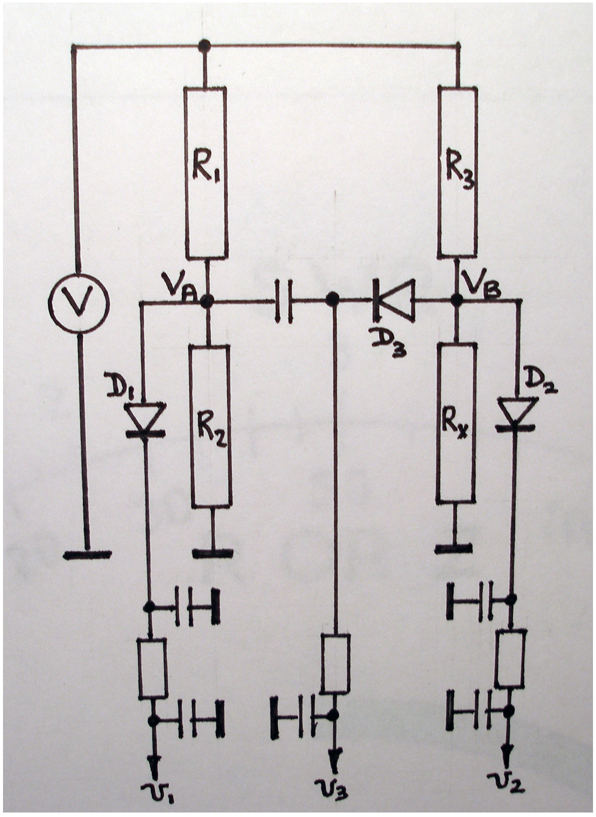


Fig.1

[Note: Errors caused by the diode forward voltage drops are minimised by using *Schottky* barrier types ($V_f \approx$ 200mV or less). A sensitive meter (50µA or 100µA) is also used. The other resistors and capacitors simply provide RF filtering].

$\mathbf{R_x}$	$\mathbf{V_A}$	$\mathbf{V_B}$	$\mathbf{v_1}$ **(=** $\mathbf{\sqrt{2}\ V_A}$**)**	$\mathbf{v_2}$ **(=** $\mathbf{\sqrt{2}V_B}$**)**	**(the magnitude of…)** $\mathbf{v_3 = v_2 - v_1}$
0	**V/2**	**0**	**0.707V**	**0V**	**± 0.707V**
50	**V/2**	**V/2**	**0.707V**	**0.707V**	**0**
∞	**V/2**	**V**	**0.707V**	**1.414V**	**± 0.707V**

Table 1

Studying this table, we see that as it does not change with changing load, v_1 **can therefore be used to *represent* applied input power or voltage**. We also see that the value of v_2 depends on the value of R_x , ranging from **0V** when $R_x = 0$ to $\sqrt{2}$**V** when $R_x = \infty$. Voltage v_2 **can therefore be used to represent R_x.** Finally, voltage v_3 is **0V** when $R_x = 50\Omega$ (SWR = 1) rising to a maximum of **0.707V** when R_x tends either to zero or to infinity (SWR = ∞ in both cases). v_3 **can thus be used to indicate SWR** on a scale calibrated from 1 to infinity (∞).
It should be noted that the R_x scale will be incorrect for reactive loads. However, v_2 is always a *minimum* at resonance - a useful indicator thereof. The **SWR** and R_x scales are clearly *non-linear* but can be established using a selection of known resistors, or by calculation (see later).
Jim VK5JST demonstrates mathematically that, irrespective of whether R_x is purely resistive or complex (i.e. **R + jX**), the resulting SWR scale ***is*** in fact correct.

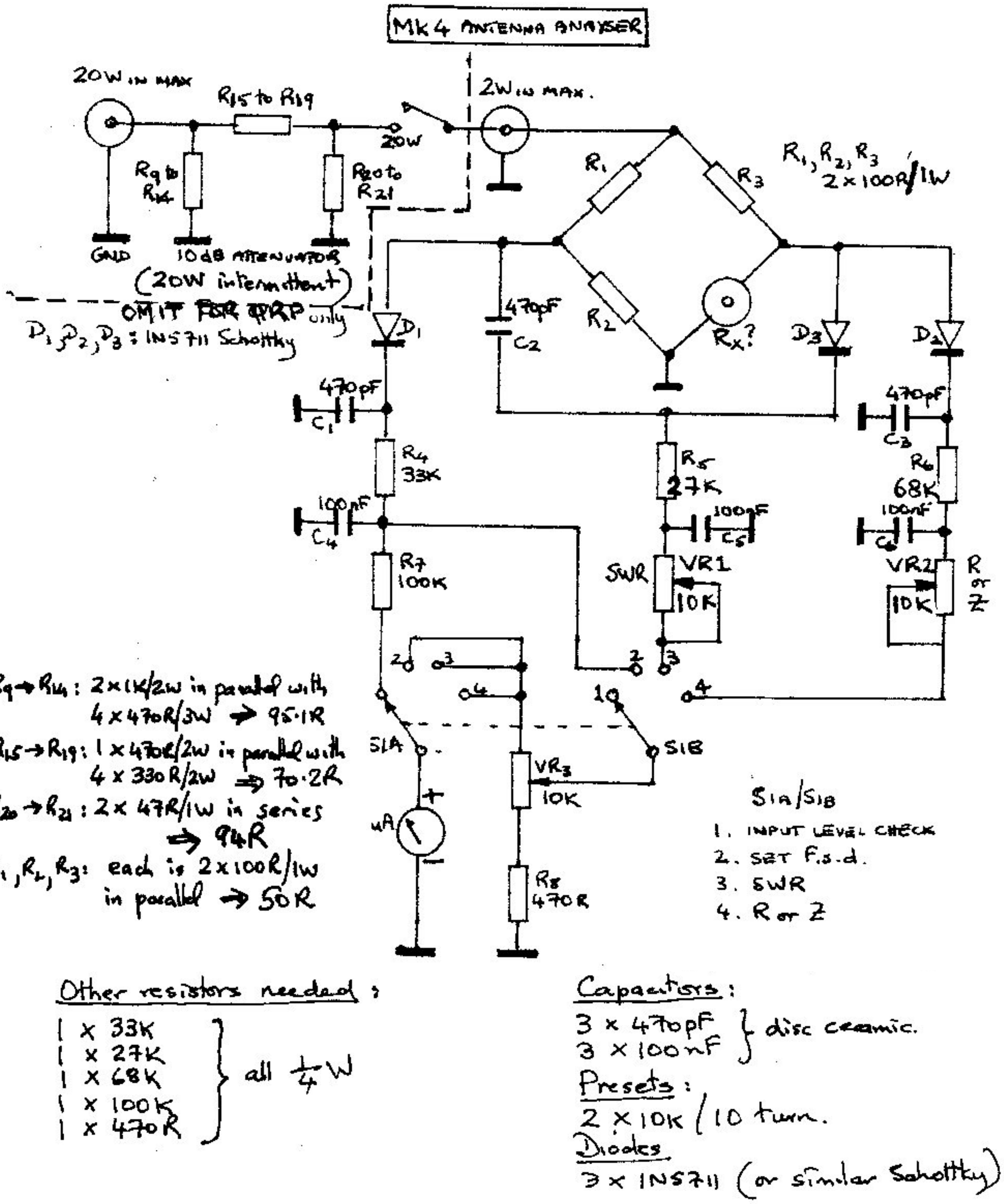


Fig.2 (including minor component value changes as of May 2013)

In the circuit diagram (**Fig 2**) above, resistors R9 to R20 form a Π-pad 10dB attenuator (**2**). Two inputs to the bridge are available. When the "HIGH" input (20W max.) is selected (TX connected to "HIGH I/P" and switch closed), the signal passes to the bridge via the 10dB attenuator which reduces the power by a factor of 10. When the "LOW" input is used (2W max.), the signal is fed directly to the bridge. After completing assembly, the analyser is pre-calibrated, WITH NO AERIAL CONNECTED, as follows:

(i) switch S1 to "I/P LEVEL" (position 1), apply 1→2W directly to the bridge (or about 10→20W via the attenuator) and check that the meter reading is in the "INPUT OK" (green) range.
(ii) switch S1 to "F.S.D." (position 2) and adjust VR_3 for full-scale deflection (∞ on SWR scale)
(iii) switch S1 to "SWR" (position 3) and adjust VR_1 to give full-scale deflection (∞ on SWR scale)
(iv) switch S1 to "R or Z" (position 4) and adjust VR_2 to give full-scale deflection (∞ on "R or Z" scale)
(v) If a good 50Ω dummy load is available, check that S.W.R. is 1 : 1 and R_x is 50Ω! (N.B. Always set F.S.D. before taking SWR and R_x readings on any aerial).

CONSTRUCTION:

Over many years managing 'O' Level Electronics projects in schools, I developed (as mentioned earlier) my own "Veroboard" assembly method which has worked well for both simple and more complex projects. The layout of the main board is shown in **Fig.3** below:

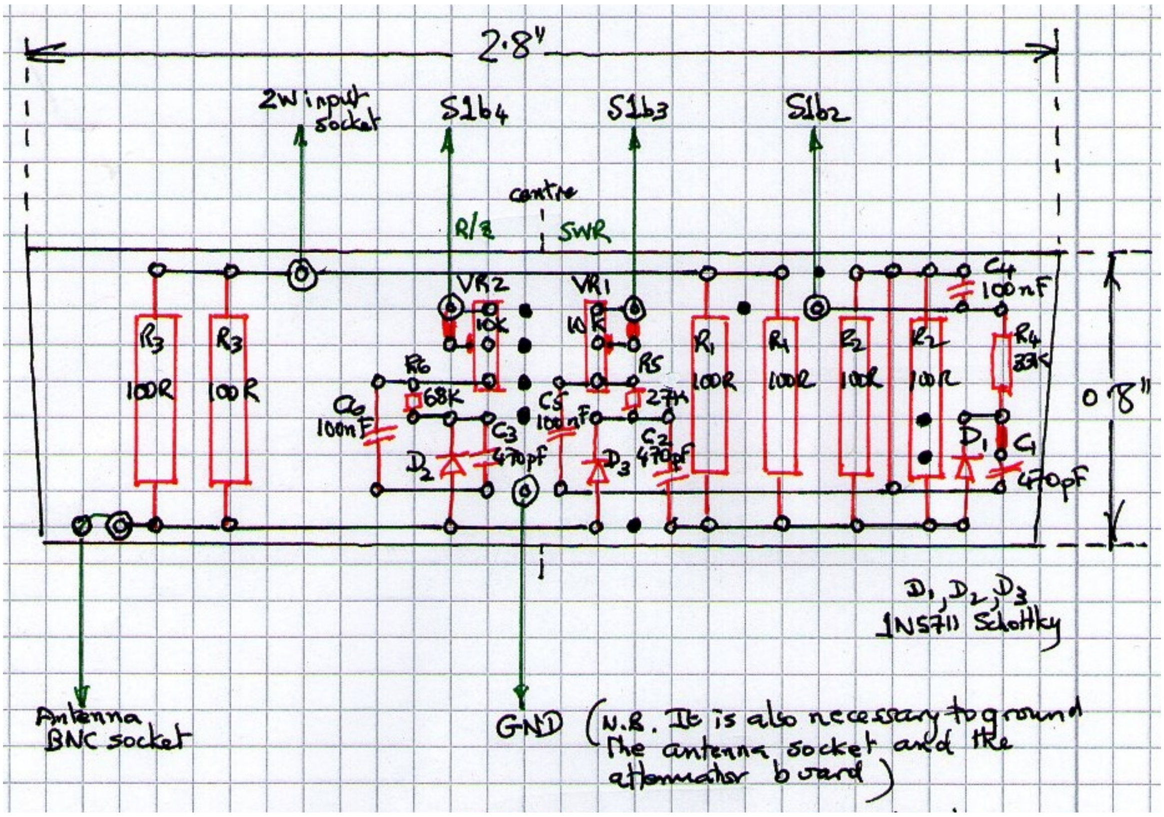


Fig.3 (including minor component value changes as of May 2013)

VR_1 and VR_2 are shown "dotted" as their exact position will depend on their shape, physical size and pin layout. The edges of the board are tapered, as the 4" x 3" x 1.5" ABS plastic boxes used are themselves tapered. The 2.9" (tapering to 2.8") x 0.8" board slots into the "guides" at each side of the box.

A slight variation of the technique, using double-sided PCB was used for the construction of the 10dB attenuator (**Fig.4**).

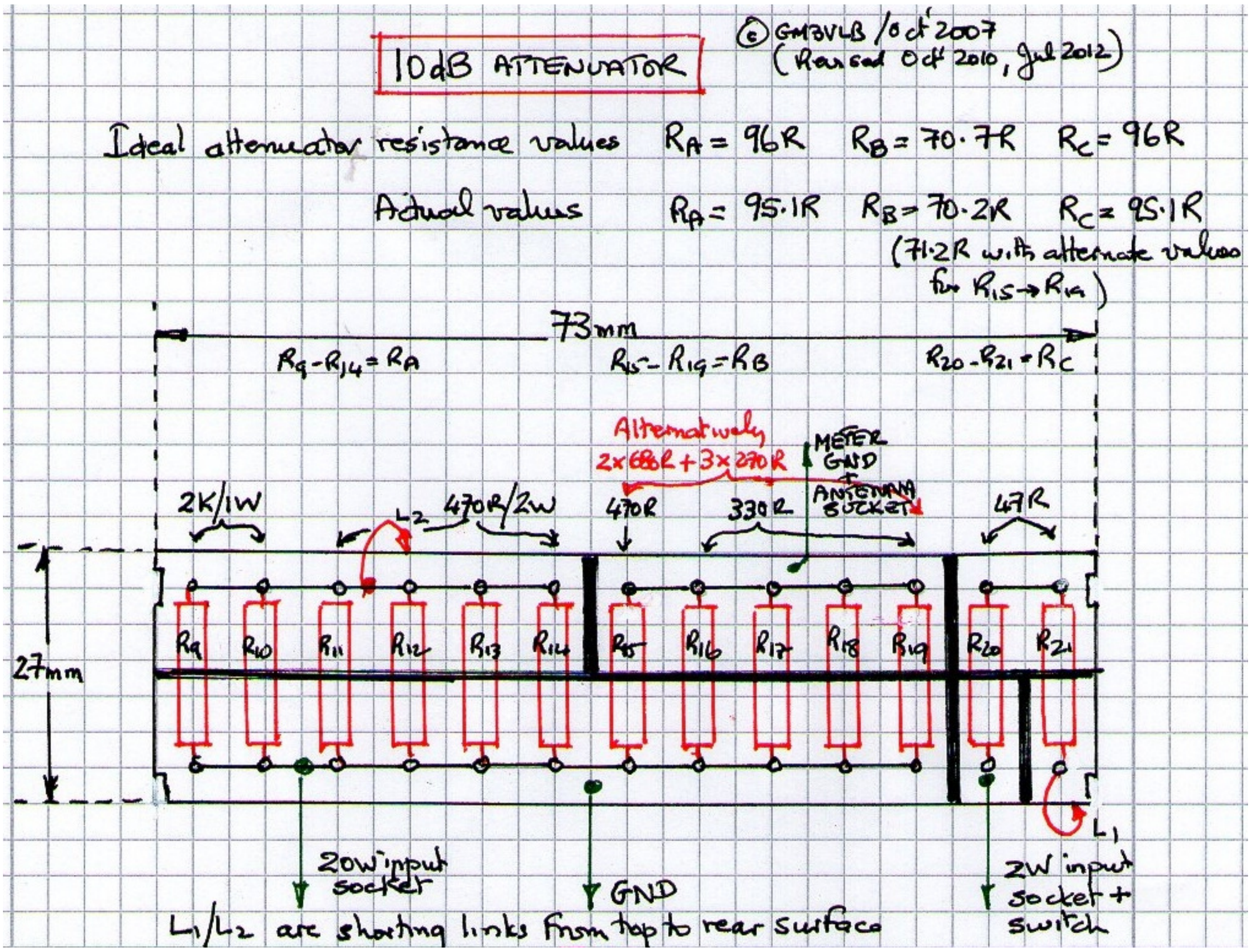


Fig.4 (including minor component value changes as of May 2013)

Creating an *SWR* scale from readings of v_3

Clearly, the scale will depend on the meter used (I was fortunate to acquire some new high quality, very linear and very good value, Russian military 50µA meters from Bulgaria on eBay!).
Whilst both scales can be created using a selection of known (non-inductive) resistors, I preferred to use some simple maths and do some (repetitive) calculations. For these, I assumed an input power $\mathbf{P_{IN} = 2W}$ and $\mathbf{R_{IN} = 50\Omega}$, so that $\mathbf{V_{bridge} = 10V}$ (r.m.s.). (from $\mathbf{P = V^2/R}$). So as not to overwhelm everyone with off-putting mathematics, I will only reproduce the final formulae from which you could produce your own scales (I am happy to e-mail or post the missing "details" to anyone requesting them)

For meters with *linear* movements (not "VU" meters for example), where the meter angular deflection $\boldsymbol{\theta}$ is proportional to $\mathbf{v}$, and $\mathbf{v_x}$ is the "unknown" voltage, it can be shown that

$$\mathbf{v_x/v_{fsd} = (SWR - 1)/(SWR + 1)}$$

and $\quad \boldsymbol{\theta_x/\theta_{fsd} = v_x/v_{fsd}} \quad$ or $\quad \boldsymbol{\theta_x = \theta_{fsd}\,(v_x/v_{fsd})} \quad$ or $\quad \boldsymbol{\theta_x = \theta_{fsd}(SWR - 1)/(SWR + 1)}$

$\boldsymbol{\theta_{fsd}}$ is of course the angle for full-scale deflection for the particular meter used (mine was 87°**).** A table of angles corresponding to chosen SWR values can thus be constructed, and a new scale produced, for any chosen meter. I found Jim VK5JST's scale points very convenient and used these. The scale is *numbered* at SWR 1, 1.5, 2, 3, 5, 10 and ∞, with 4 intermediate graduation marks between SWRs 1 and 1.5, 1.5 and 2 and 2 and 3, as well as single marks at 4, 6, 7, 8 and 9.

N.B.: In the case of SWR, the *forward voltage drop* V_f of the diode is *not* a variable, and, as stated previously, the scale is also correct for *reactive* loads.

Creating a *resistance* scale from readings of v_2

In this instance, diode forward voltage drop IS a variable. In the relevant calculations, I have assumed a typical Schottky value of 0.2V. As a consequence, $\mathbf{R_x = 0\Omega}$ occurs a shade *below* actual zero volts, whilst $\mathbf{R_x = \infty}$ occurs a shade *above* actual f.s.d**.** As a further consequence, the $\mathbf{R_x}$ scale is in fact only correct for one specific level of input power which in this design is $\mathbf{P_{IN} = 2W}$ (or **20W** via the attenuator). The scale IS correct at ½ f.s.d., i.e. $\mathbf{R_x = 50\Omega}$. However, at other power levels, the error is so small as to be insignificant. For example, if $\mathbf{P_{IN}}$ were only **0.2W** (i.e. an unlikely *10 times* less), there would be a progressively increasing error above and below 50Ω. For example, for a *real* $\mathbf{R_x}$ of 15Ω, the needle will be just over 1.5° too low, representing an *apparent* $\mathbf{R_x}$ of 13.5Ω – hardly discernible, and quite insignificant in the matching process.
Similarly, for a *real* $\mathbf{R_x}$ of 200Ω, the needle will be just under 2° too high, representing an *apparent* $\mathbf{R_x}$ of 228Ω, again hardly discernible and fairly insignificant. A power $\mathbf{P_{IN} = 2W}$ was chosen as the best compromise – this instrument was not designed as a *digital ohm-meter* – nor was it intended as an accurate scientific measuring instrument. It is a cheap, simple, hand-held, supply voltage-free, *informative* instrument, which allows the user to set up his/her aerial by indicating, fairly accurately, S.W.R. and input resistance at resonance. If necessary, simple transformer matching can then be used at the aerial input, thus dispensing with the lossy, inappropriate A.T.U. (another costly gadget). Now for some maths…

For an unknown resistance $\mathbf{R_x}$, $\mathbf{v_2}$ (see **Fig.1**) $\mathbf{= v_x = 14.14\,[R_x/(R_x + 50)] - 0.2}$

We need to *calculate* $\mathbf{v_x}$ for each value of $\mathbf{R_x}$ anticipated (I again used VK5JST's values of 10, 20, 30, 40, 50, 100, 200, 500 and ∞, with intermediate scale points – see photo')

If we *choose* "half f.s.d." to occur at $\mathbf{R_x = 50\Omega}$, $\mathbf{v_{fsd}}$ computes to be **13.74 volts.** Each scale point angle $\boldsymbol{\theta_x}$ can then be calculated by substituting the values for $\mathbf{v_x}$ (calculated above) in the following formula):

$$\boldsymbol{\theta_x = v_x\,(\theta_{fsd}/13.74)} \qquad (\theta_{fsd} \text{ is of course the meter f.s.d. angle})$$

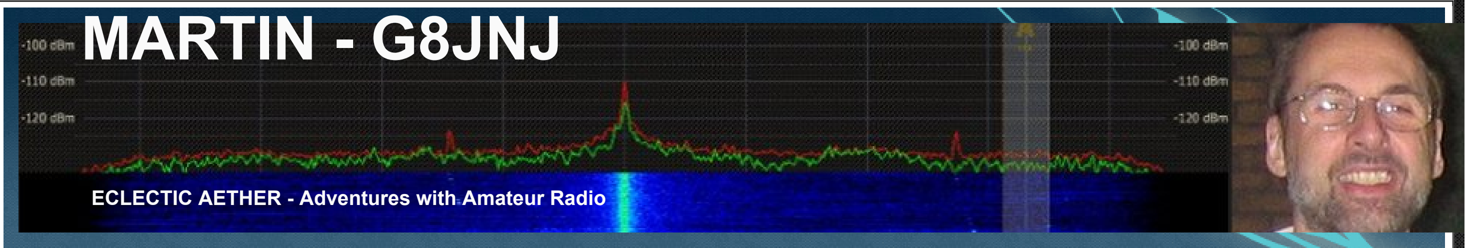
FINALLY...High SWR presents NO risk of damage to the rig. If the aerial I/P is open-circuit, the impedance presented to the rig is **100Ω** (an SWR of 2 : 1). Similarly, if it is short-circuit, the impedance is **33.3Ω** (an SWR of 1.5 : 1). Both values are thus well within the safety limits of all transmitters.

I now keep this analyser in my own car for tuning my /M aerials (no risk then of losing/damaging my MFJ259B). The final Mk4 version uses the Russian 50μA meter and forms the basis of the present article. I have enough components to assemble a limited number of complete instruments at a cost of £70 (inc. P&P) – payable in advance. (I have been let down too many times!). For those wishing to "have a go", but feel that calibrating an existing meter is a bit too involved, I can supply a limited number of re-scaled 50μA meters (identical to mine) for £20 (inc. P&P).

Acknowledgements:

(1) Jim Tregellas, VK5JST (http://users.send.com.au)(e-mail: endsodds@internode.on.net), who planted the seeds, and in true radio amateur spirit, was free with his help and advice. (N.B. Jim's "Q-meter" design is also well worth looking at).

(2) 10dB Π Attenuator: p151, RSGB Radio Data Reference Book, by George Jessop G6JP



Revolutionary New Design

Please note that this webpage was originally intended to give guidance about how to improve the performance of an antenna that is similar in design to that of the Comet CHA-250.

In the time since I originally wrote this webpage, I have developed a completely new type of broadband vertical antenna, the Terminated Coaxial Cage Monopole (TC2M), which does not require a tuner, is simple and cost effective to construct, and offers performance that is comparable to, or better than, other similar sized multi-band antennas.

Many prototypes of the antenna have been built and tested for long periods of time, and the final optimised design has been granted a UK Patent.

Information about this new antenna, including construction information, was featured in the May & June 2014 issues of Radio Communications Magazine, published in the UK by the Radio Society of Great Britain (RSGB). Following its publication, I was awarded the RSGB 2015 Bennett Prize in recognition of a 'significant contribution or innovation which furthers the art of radio communication'

Full details are now available for non-commercial use.

Click here for a PDF copy of the original article

Or alternatively visit the TC2M Antenna Website for more details www.tc2m.info

I strongly encourage you to try the new design as it provides much better performance than the antenna featured on this web page.

G8JNJ Broadband HF Vertical Antenna - Requires no tuner - copied by many companies

The following notes show the design and construction of a Broadband HF Vertical antenna which does not require a tuner, and which is capable of providing moderate performance on all bands from 7MHz to 28MHz (reduced performance from 3.5MHz to 51MHz).

It follows an extensive period of investigation with a Comet CHA-250 'style' antenna using a specially constructed 5:1 transformer. I tried and rejected many other designs before finally arriving at this version.

The basic design and principles originally outlined on this page in 2008 have been copied by many companies (mainly in North America) without any acknowledgement of the source of the copyrighted design. They sell their products for many $100's of US dollars and continue to make outlandish claims about their performance.

So if you wish to experiment and construct a fairly compact multiband antenna, that works moderately well, doesn't require a tuner and can be built for less than £20 if you shop around for parts, this may be for you.

Please note that this antenna will NOT out-perform a beam antenna at 100ft on the HF bands or a 260 ft long wire on the LF bands - It works about as well as a 7m long vertical antenna can do !

I find this antenna particularly useful for HF beacon monitoring using Faros software, WSPR personal beaconing or HF ALE operation using PC ALE (most of which are free).

You can compare the performance of this antenna against others, by taking a look at my transmit and receive signal reports for various bands, which have been automatically logged on the WSPR database.

Folks considering making a G5IJ antenna (which is not what it seems as the concept is flawed, it's actually equivalent to a thick wire radiator fed via an impedance transformer, with the coax acting as a counterpoise) or those using fishing poles, 4:1 baluns and remote auto-tuners may also be interested in this design, which has minimal loss.

The principle of operation is that a specific length of radiating element is chosen so that it presents an average value of impedance on most amateur bands. A special matching transformer is attached at the feed point to convert the antenna feed impedance to something close to 50 ohms.

Note that all of these 'easy to match' antennas work in more or less the same way by incorporating resistive loss into the matching transformer, or by adding external resistors such as the Diamond BB7V and BB6W.

Most have a low value of Shunt resistance which makes the SWR look good when a length of wire with a high feedpoint impedance (Voltage fed) is attached (1/2 wave and even multiples). This can be observed as providing a low SWR when no antenna wire is attached to the transformer.

Some others also include a high value of series resistance which makes the SWR look good when a length of wire with a low feedpoint impedance (Current fed) is attached (1/4 wave and odd multiples) or an electrically short wire is used. This can be observed as providing a low SWR when the output of the transformer is shorted to the ground connection of the screen of the coax.

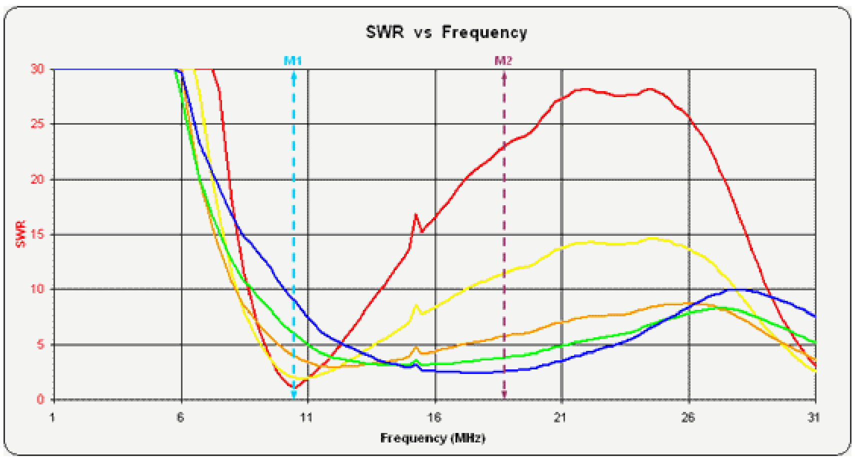
When a good low loss transformer is used, both of the above tests should produce a very high SWR reading, as there are no transformer losses to mask the bad match (open circuit and short circuit).

When a resistor is connected across the transformer in order to improve the match, it will absorb a lot of the applied power that would ideally be radiated. The value of the resistor will determine how much power is wasted and what the worst case SWR will be. If the transformer has a resistor that is equal in value to it's secondary impedance then it will dissipate a large amount of the applied power, but with no antenna connected the SWR will be close to 1:1. The exact amount of power that will be radiated will depend upon the antenna wire feed impedance at a particular frequency, but it is likely to radiate more power when the antenna feed impedance is lower than the the value of load resistance.

If you use a resistor that is twice the value of the transformer secondary impedance then the maximum SWR with no antenna connected will be 2:1. This is usually the maximum SWR most radios can withstand without the SWR protection operating to reduce the output power to a safe level. As the value of resistance is higher than in the previous example, less power will be wasted heating up the resistor and more power will be radiated.

The antenna can be ground mounted or attached to an insulated pole, which will further improve the HF performance (as shown later).

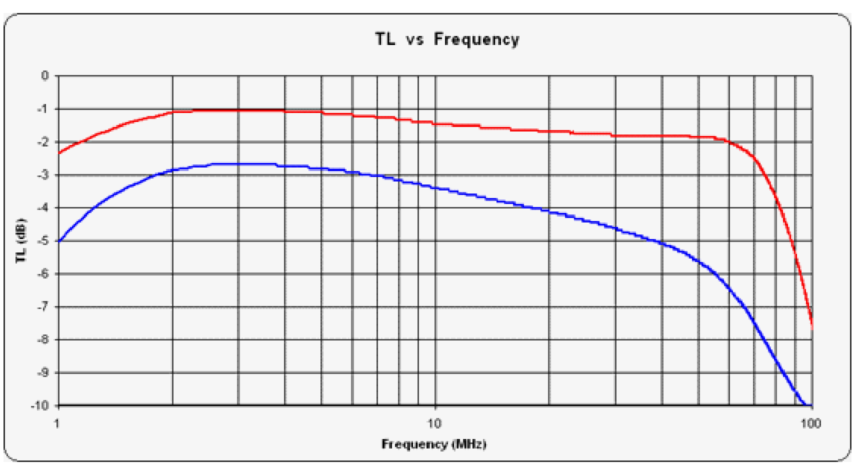
The graph below shows the measured VSWR of a 6.5m vertical wire antenna (supported on a 10m fishing pole) fed against 10 buried radials, and terminated with differing values of resistive loads.



The Red trace is with a 50 ohm termination, Yellow with 100 ohm, Orange with 200 ohm, Green 300 ohm and Blue with 450 ohm. So the lowest overall VSWR is with a resistive termination impedance of around 200 to 300 ohms. The two markers show the 1/4 resonant frequency (M1 at 10.5MHz) and the 1/2 wave resonant frequency (M2 at 21MHz).

If some additional loss through the transformer and approx 2dB loss through coax cable is factored in, and the radiating element and radial system are fine tuned, it is possible to achieve a VSWR of less than 2:1 on most amateur bands.

My improved transformer design still has some through loss, but it is much less than the original Comet clone. This results in several dB improvement in antenna gain compared to the Comet version (A/B measurements made with remote receiver).

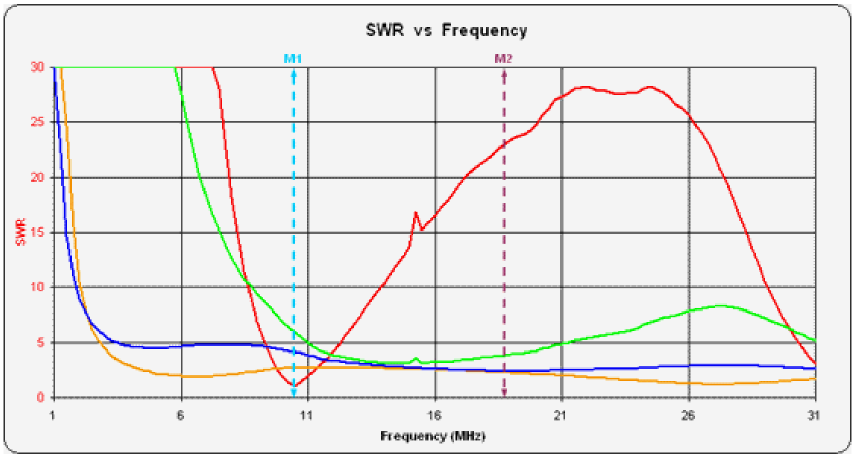


Graph showing loss through transformers. The Blue trace is the Comet clone and the Red trace is my improved transformer.

The performance of the new transformer is much better than previous versions I have tested. I am no longer able to measure any improvement in radiated signal strength by connecting a remote tuner at the end of the low loss coax feeding the antenna (apart from 1.9MHz & 3.6 MHz where an improvement of approximately 2dB was observed).

The through loss is much lower than the original version and the antenna design trades improved radiation efficiency for slightly a higher VSWR figure.

However because of the reduction in through loss (and its masking effect on VSWR), the VSWR is slightly higher than that of the Comet clone.



The graph above shows the VSWR measured at the base of a 6.5m high vertical supported by a 10m fishing pole. The Red trace shows the 6.5m wire fed directly. The Green trace shows a 300 ohm resistive termination, the Orange trace shows the vertical fed via a Comet style transformer, and the Blue trace shows the vertical fed via my modified version of the transformer. The two markers show the 1/4 resonant frequency (M1 at 10.5MHz) and the 1/2 wave resonant frequency (M2 at 21MHz).

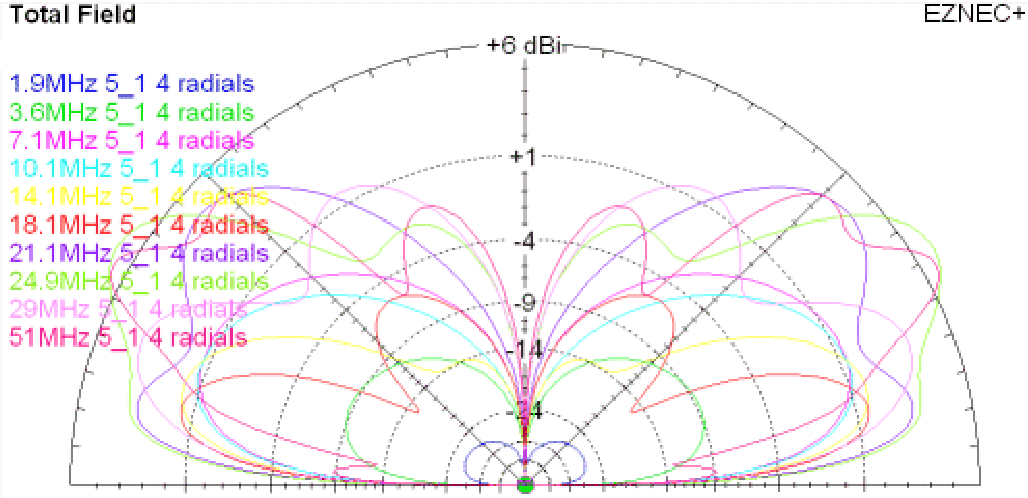
Note that the transformer adds a progressively greater shunt resistance at low frequencies which improves the VSWR. Further improvements in matching can be obtained by using short radials, or counterpoise wires instead of a large earth system. This increases the resistive component of the antenna impedance at the lowest frequencies. Although this reduces the antenna gain, it makes very little difference to the overall performance on the low frequency bands, as the antenna is far too short to be efficient on these frequencies anyway. These facts may horrify you, but a lot of commercial antenna manufacturers use similar techniques, they just don't tell you !

Many people would also argue that 2 or 3dB loss through a matching network is too high. But my tests suggest that even a good ATU can add between 0.5 to 1.5dB dB loss, and that many 4:1 baluns, especially those wound on iron powder cores can also add a further 1 to 3dB of loss, especially when feeding low impedance or highly reactive loads. So 2 to 3dB loss may be fairly average, and I would argue that many amateurs already have this amount of loss in their transmission path without realising it, as they have never taken the time to measure it.

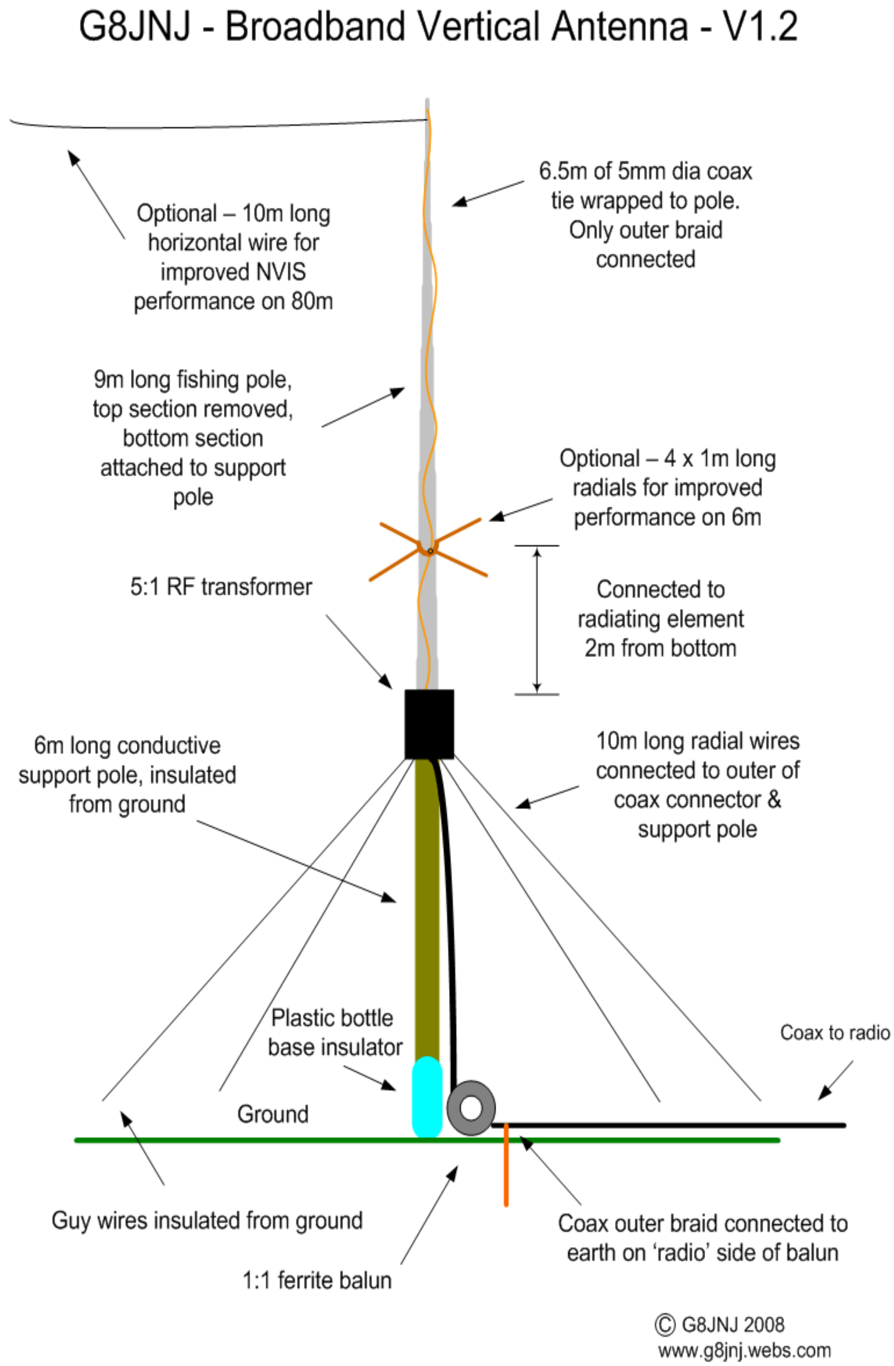
The chart below shows the VSWR measured via a 10m long cable at the base of the antenna. Note that any additional feeder losses will further improve the figures. For example when a typical length of coax cable (with 1 to 2 dB loss) is connected the VSWR will improve further. e.g. A 3:1 VSWR load will measure as 2.3:1 with a 1 dB cable loss and 1.9:1 with 2dB cable loss.

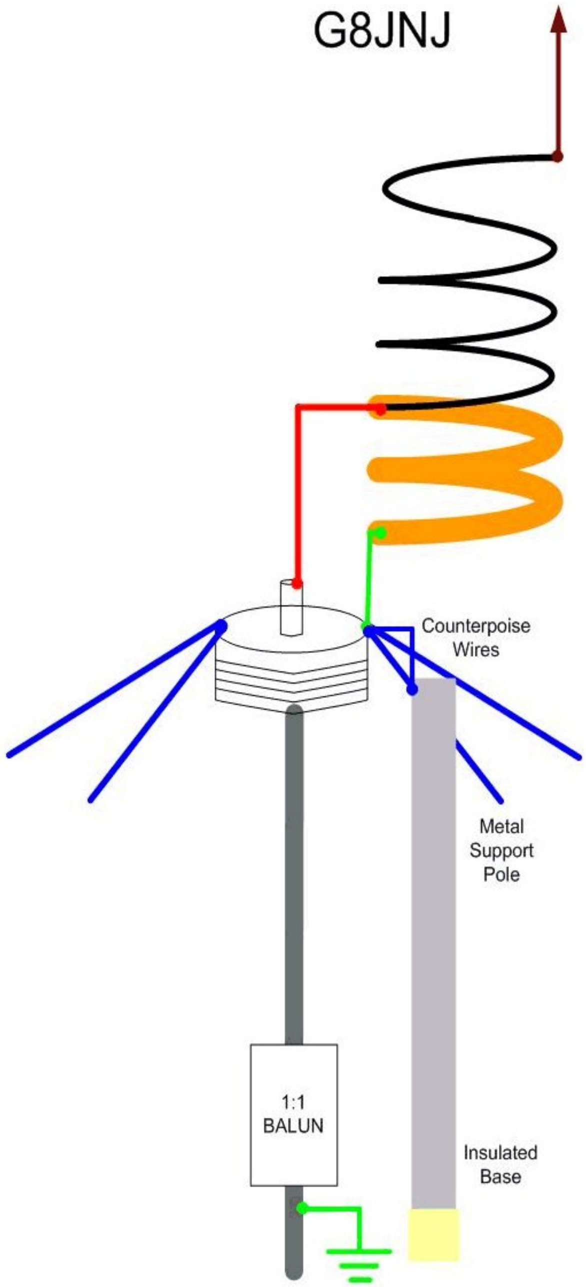
Frequency	Gain	VSWR
1.9 MHz	-26dBi	8.5:1
3.6 MHz	-6dBi	4.2:1
7.1 MHz	+1dBi	2.1:1
10.1 MHz	+1dBi	1.75:1
14.1 MHz	+1dBi	1.46:1
18.1 MHz	+3dBi	1.94:1
21.1 MHz	+4dBi	2.25:1
24.9 MHz	+4dBi	2.73:1
29 MHz	+2dBi	2.38
51MHz	+1dBi	1.5:1

A better indication of the performance can be obtained from the plot shown below. Note that the angle of radiation tends to become more elevated on 29MHz & 51MHz slightly reducing the useful gain.



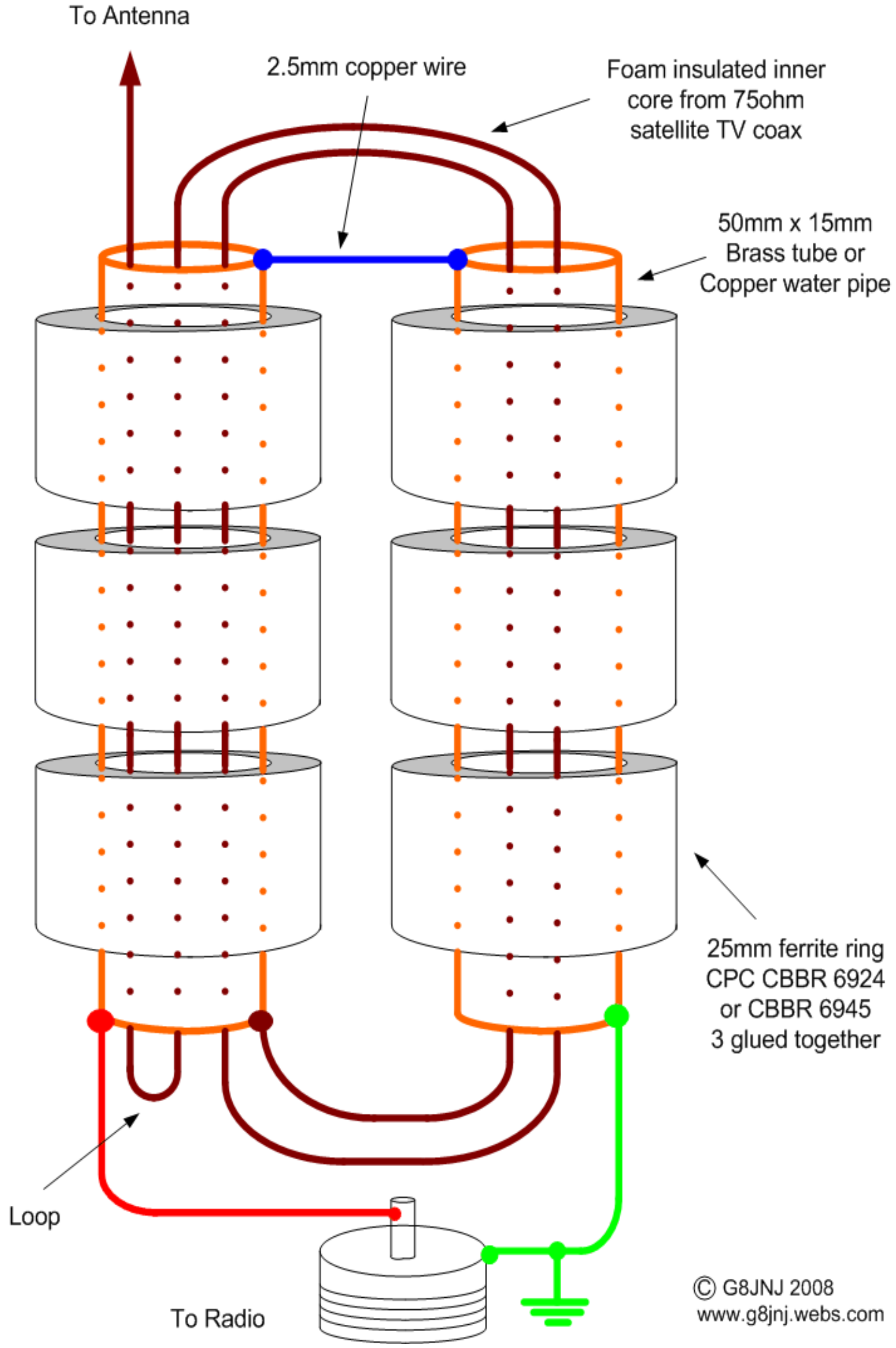
The basic components of the antenna are a 9m fishing pole, 6m support pole, home built 5:1 transformer and some wire. These are configured as shown in the diagram below.


G8JNJ - Broadband Vertical Antenna - V1.2
Optional – 10m long horizontal wire for improved NVIS performance on 80m
6.5m of 5mm dia coax tie wrapped to pole. Only outer braid connected
9m long fishing pole, top section removed, bottom section attached to support pole
Optional – 4 x 1m long radials for improved performance on 6m
5:1 RF transformer
Connected to radiating element 2m from bottom
6m long conductive support pole, insulated from ground
10m long radial wires connected to outer of coax connector & support pole
Plastic bottle base insulator
Coax to radio
Ground
Guy wires insulated from ground
1:1 ferrite balun
Coax outer braid connected to earth on 'radio' side of balun
© G8JNJ 2008
www.g8jnj.webs.com



A diagram showing construction of the 5:1 transformer is shown below. Note that this is not the same as the Comet balun details of which can be found here. The ferrite rings seem to be similar to type 33material and can be obtained from CPC part number CBBR6924 or CBBR6945 Both of these are supplied in packs of five and should just slide over standard 15mm dia copper water pipe. Unfortunately some of the ferrite rings I have bought recently are slightly smaller, and so will not fit over standard size copper water pipe. If you encounter this problem you may have to buy brass tubing from a model shop instead.

5:1 Broadband RF Transformer Construction



Here's one I made earlier !

Note - Since I originally built this antenna. Several people have tried to use it with an auto-tuner in order to improve the performance. This is not likely to make much difference, because of the losses in the transformer. If you do wish to achieve better efficiency with an auto-tuner. Then I suggest you use the 4:1 Unun wound on type 52 Iron powder material shown at the bottom of the BBV7 section of this page.

The 1:1 balun which is used to isolate the coax feed at the base of the antenna uses five of the same ferrite rings glued together with five turns of coax passed through the centre. Ideally you need at least four of these in order to achieve the best results.

FAQ's - Answers to questions I have been asked about the antenna

How well does it work ?

It depends upon what you choose to compare it against, and on which bands. For example I would expect it to perform fairly well against something like an 18AVT on the HF bands, however it will not work anything like as well as a 132ft wire on the LF bands. I estimate 8 to 10dB worse on 80m and 20 to 30 dB worse on 1.9MHz. The only fair comparison would be against the same radiator and counterpoise, but fed with an auto-tuner in place of the matching transformer, as this would represent the best performance you could achieve in this configuration. This is how I measured the antenna performance and the standard I judge it against. By its very nature the transformer version will be worse than this ideal, but I think it's worth trading a few dB of additional loss in order to obtain broadband operation. Note that since I originally built this antenna. Several people have tried to use it with an auto-tuner in order to improve the performance. This is not likely to make much difference, because of the losses in the transformer. If you do wish to achieve better efficiency with an auto-tuner such as an LDG Z11Pro. Then I suggest you use the 4:1 Unun wound on type 52 Iron powder material shown at the bottom of the BBV7 section of this page

In summary it compares favourably with other multiband vertical antennas of similar height on the HF bands but not quite as well on the LF bands.

Why can I hear stations, but they can□t hear me ?

You would expect that if you can hear stations you should be able to work them, however the lower noise floor on receive means that you can sometimes hear stations on the LF bands which would otherwise be masked by QRM on larger antennas. In summary the signal level is lower but the signal to noise ratio is much better.

You can hear DX with it, and it seems to work very well on RX, but perhaps not quite as well on TX, which seems strange as you should expect reciprocal performance. I can measure my transmitted field strength remotely and compare the antenna against other designs and it seems to match dB for dB on TX and RX (apart from obvious absolute gain differences). Yet sometimes I call stations on the vertical and they don't come back, switch over to the other antenna and they do, even though on receive they are the same strength, it's a very odd phenomenon but I suspect it's simply down to a better receive S/N ratio on the vertical (as opposed to the absolute signal strength). I find it works well as a receive antenna on 160m and one constructor John, G4IJD, has heard a ZL station on 80m at reasonable strength. In comparisons I have found it outperforms a Datong active antenna mounted at the same height.

What is the resonant frequency of the antenna ?

The basis of the antenna is that it is NOT resonant on any of the desired frequencies. It is designed so that the impedance presented by the radiating element on wanted frequencies is close to the secondary impedance of the transformer for maximum energy transfer. The use of a 7.1m radiating element is not accidental (the radiating element is actually a ¼ wavelength long at 10.4MHz). It□s intended to present a manageable impedance on the desired amateur bands, whilst not being too long (under 5/8 wave) for effective operation on 10m and 6m. Making the vertical element longer would cause the angle of radiation to increase in elevation, reducing the useful gain.

How can I further improve its performance ?

The main problem is balancing the parameters of maximum vertical length (which needs to be kept below 5/8 wave at the highest frequency), sufficient length to be efficient at the lowest frequency, a moderate feed impedance (to suit the transformer ratio) for the radiating element at all frequencies required for TX, and ideally some horizontal component to keep the folks who require NVIS performance on 80m happy.

You could replace the transformer with an auto-tuner, increase the number and length of radials, increase the height of the support pole, use lower loss coax, increase the transmit power, add an 80m long offset top loading wire. The permutations are endless - but it□s not the antenna you started with !

How can I make it work better on the LF bands ?

Performance on 80m is a bit of a compromise. I think it□s about 6dB down on an equivalent length radiating element and counterpoise, but with an auto-atu in place of the transformer. Feeding the transformer with a remote atu made about 2dB improvement on 80m over the transformer alone. On the HF bands adding a remote atu made very little difference.

However the perceived lack of performance may be due to several factors. One is that it□s a lot shorter than a ¼ wavelength on the LF bands, another is that being a vertical it has very little upward radiation, so it is a poor performer for NVIS coverage on 1.9 and 3.6MHz. Hence once you get outside the ground wave coverage there is nothing until past about 500 Miles so it□s very poor for semi-local contacts.

The main difficulty is managing the impedance presented by the radiating element on the LF bands. For example a 7m long wire over an average ground plane on 1.9MHz is typically 10 □ J1310 and on 3.6MHz 10.5 □J640. As you can see the resistive element is very small in relation to the transformer secondary impedance and the reactive component is very much greater and capacitive. With my transformer design I have tried to roll off the impedance ratio at the LF end to get a closer match to the radiating element but it□s still a long way out. From this I hope you can get a good feel for what design parameters can be traded, and those which will remain a compromise. The ideal efficient broadband antenna is a □holy grail□ for antenna designers, and I□m sure there are a lot more qualified persons than myself who haven□t found it yet.

John, G4IJD suggested using the antenna in a horizontal configuration. I have been playing with this idea, and the best configuration so far seems to be something like an 11.2m horizontal wire at 10m above ground, with the transformer also at 10m, fed with coax and with the 1:1 choke balun fitted to the coax at 2m above ground.

However I suspect that the mechanical difficulties of supporting the transformer at 10m may make an inverted L easier to implement.
To achieve this all that's required is the addition of a horizontal wire at the top of the existing vertical section.This would add an NVIS component, increase the radiation resistance and improve the efficiency on 80m. The question is, how long should the horizontal wire section be. I suggest keeping the vertical section the same length as the original design, but add a horizontal wire of length 12.2m or 27.2m long, to make the total length of radiating element either 19.2m or 34.2m.

These lengths should not present an impedance of much greater than 1K on any of the desired transmit frequencies.You can use the LVD programme on this website to give an estimation of feed impedance if you wish to experiment with other lengths (also see my notes relating to auto-tuners). Using a 12.2m horizontal top wire will add a useful NVIS component on 3.6MHz, but you really need to get upto 27.2m long before it becomes effective. However at this point the antenna is starting to become fairly large. Another option would be to use two top (or more) wires of differing lengths say a ratio of 1/3 & 2/3 in order to provide mismatched currents which would result in better NVIS coverage.

One other idea I have tried, is to add a helical winding at the top of the vertical element in order to improve performance on the LF bands without adversely affecting the HF bands. 400 turns of close spaced wire 2m down from the top of the radiating elment with about another 0.5m of wire above it works well for 160m and also provides some improvement on 80m.

Another alternative would be to try using the transformer to feed something like a 60m dia horizontal loop, which would also improve NVIS coverage on the LF bands.

How can I make it work better on 6m ?

Performance on 6m is reduced beacuse of the length of radiating element. Ideally a vertical antenna should not be longer than 5/8 wavelength, or most of the radiated energy tends to fire up towards the sky. I have tried modeling the antenna with a four element capacity hat at various heights, and have found that four 1m long radials attached to the main vertical radiating element 2m above the feed point, results in approximately 6dB more gain towards the horizon. There is still some energy radiated up towards the sky, but this is more than offset by the improvement in gain at low angles. This modification does result in a slight reduction in gain on 10m, but this may be a worthwhile trade. So far I have not had the opportunity to try this, but hope to do so in the near future.

Could I use some other form of loading ?

There is a problem in adding any form of loading as it introduces varying impedances at other frequencies. A loading coil or trap which is introduced to improve performance on the LF bands will have an impact at the HF end. The least problematic method would be to add a loading coil towards the top of the radiating element and / or capacitive loading. A technique such as Petlowany loading is also a possibility, see my washing line antenna.

John, G4IJD, has been experimenting with capacity hat loading, using four sloping wires from the top of the radiating element. I have included some of John's comments below

>>>Having first established that my effort came close to your results (base of antenna still at about 3m agl) my "gut" feeling was that T (or maybe capacity since T is really out of the question) loading would improve the match on top band and 80m without significantly altering the loading on the HF bands.

For test purposes I have attached 4 wires, all equal in length to the main element, to the top of the antenna.By bringing these wires out from the base I can see any effect on the matching quite easily.

Using all four wires extended out to about 5m from the base at 90 degrees to each other, the VSWR on top band drops to about 1.4:1 when measured at the transmitter and so an ATU is not required. Matching on all other bands can then be taken care of by an ATU. To return everything to normal I simply connect all wires together at the base of the main element.Haven't tried all combinations yet but will keep you posted.

I have no idea what effect this has on the radiation pattern but in my situation the extra wires double up as guy wires and stabilise the antenna in high winds thus boosting neighbour confidence. Of course all this is possible because the base is easily accessible from a ladder.

I think this antenna will appeal to a lot of people as long as they read all your notes and don't expect too much from it. As an all band convenience antenna it's ideal for me. I can think several uses for a second one. <<<

More analysis of this is required, but it struck me that the wires could be brought bact to the base of the radiating element to form a cage folded monopole, perhaps something like this. Some broadband military HF antennas use this technique, often in conjunction with a high power terminating resistor.

Why did you use coax cable as the radiating element ?

When I modelled the antenna I found I got better results using a larger diameter conductor. I reduced the diameter until the results started worsen. The best compromise was to use a diameter of around 10mm, and coax cable was the cheapest option. If you have aluminium tube or an old CB antenna this would be better still. Just cut the length so that it is a ¼ wave at 10.4MHz as this will give the correct matching impedance at other frequencies. If you need to use a shorter support pole it is possible to use a lazy helical winding for the radiating element, say up to 4 turns per metre length it should be OK, however this technique tends to introduce unpredictable secondary resonances which could put lumps and bumps into the frequency response.

How critical is the height of the mounting pole and the length and number of radials ?

They are not too critical, for example, three 5m long radials would be fine, however I would suggest that all the radials or counterpoise wires and the mounting pole are not connected to ground and the length does not exceed 10m. You may wish to experiment with the lengths and angle of dangle to achieve the best impedance match on the required frequencies. On the LF bands longer radials would be better but you could try adding say two inductively loaded radials tuned on the LF bands of interest. As I previously stated you can mount it higher or lower within certain limits. But if this is not easy you could consider ground mounting with at least four radials. In this case adding more radials will further improve the performance.

I have obtained very good results by mounting this antenna on top of a building with a metal clad roof. I did not use any radials, but mounted the transfomer close to the edge of the roof and connected it to the cladding with a short metal strap.

If either of these two methods are not possible, you can ground mount the antenna and connect it to as many radials as possible. However the gain will be significantly lower than using an elevated feed and counterpoise / radials.

Why is there a 1:1 choke balun at the base of the mast ?

The purpose of this is twofold. It is designed to provide a high impedance break in the feed cable at a specific point so that the vertical section of the coax (and the support pole it runs along) is lifted above ground to form a counterpoise, the whole antenna then becomes similar to an off-centre fed vertical dipole. If the balun was fitted at the top of the pole, there would still be coupling between the outer of the coax below the balun and the support pole. The second purpose is to prevent electrical noise and other unwanted interfering signals which may be carried on the outer of the coax from being conducted into the receive path. It also eliminates RF on the coax when used for transmit purposes.

Please note that simply using coiled coax as a balun does not provide a high enough choking impedance for this purpose.

Can I use chokes from CRT monitor cables or some others I have in my junk box ?

I have tried a large selection of ferrite materials, including some which I have recovered from scrap CRT PC monitors. There is a very large variation between types (even those from the same make and model) I think they just use whatever they can get hold of. If you have a large number (at least 10 and ideally 30 - 40 or more for 1.9 & 3.6MHz) and thread them over coax they can be used for the 1:1 balun to suppress noise which would otherwise be induced on to the received signal. However the variation in characteristics makes them difficult to use for the transformer, if you wish to obtain repeatable results. Also be very careful about ring cores you buy at radio rallies or on e-bay. Many of these are actually made from iron powder, and are designed for low frequency (əMHz) use in switched mode power supplies. They are not suitable in this application. If you have an impedance measuring bridge you can test them to see if they are made of ferrite. As a rule of thumb with one turn you should obtain about 2.5uH at 2MHz, 1uH at 10MHz and 0.4uH at 30MHz for a 20 x 30mm core with 7mm dia hole if it is similar to type 43 material. However if you do this I cannot guarantee it will work as well as a transformer made with the specified parts.

Do I have to use copper or brass tube ?

No, Wolfgang, OE1MWW has successfully used braid from RG213 coax. He also tried using just a single wire loop, but found that the closer coupling provided by the coaxial tube winding produced much better results. See further down the page.

How can I increase the power handling ?

The main problem with power handling seems to be at frequencies around 18 to 22MHz where the length of radiating element is around ½ wavelength which presents a high load impedance. This results in power being dissipated in the ferrite material used in the transformer core. Using a metal box and heatsink and bonding the ferrite material to the box with thermally conductive epoxy resin may help. More cores can be added, but this will lower the frequency at which the maximum impedance transformation occurs, which may increase loss on the LF bands. Another suggestion is that the ferrite cores are replaced with powdered iron and the quantity increased. You may need to use 20 or more powdered iron cores to achieve the required inductance. The input impedance with no radiating element connected should measure at least 200 ohms at the lowest operating frequency.

Why did you use the inner from coax cable for the transformer secondary winding ?

I picked this for its high voltage insulation properties. Most foam insulated satellite TV coax has a breakdown voltage of around 1.8KV. This should be adequate for power levels up to about 200watts on frequencies where the radiating element presents the highest impedance (and requires maximum feed voltage) to the transformer.

G8JNJ - 01/06/2014 v4.3

Who else has made one ?

despite the fact that my original design artwork was clearly marked © G8JNJ 2008, several companies have copied and sold key parts of this design without crediting the source.

I'll let you guess who they are, as the manufacturer of one of the four shown below threatened to sue me for putting a photo showing the inside of **"their"** matching unit on my website !




Update

At least these guy's are a bit more open, but still no credit to the source.

In early 2016 a video entitled "Inside of an Alpha Match" was posted on YouTube by user "steinhest" showing the inside of a matching unit as sold by Alpha Antenna.

Follow this link to the video:-

www.youtube.com/watch?v=IbLAeqqRdNc

Here's a still frame captured from the video

In the comments section of the You tube video

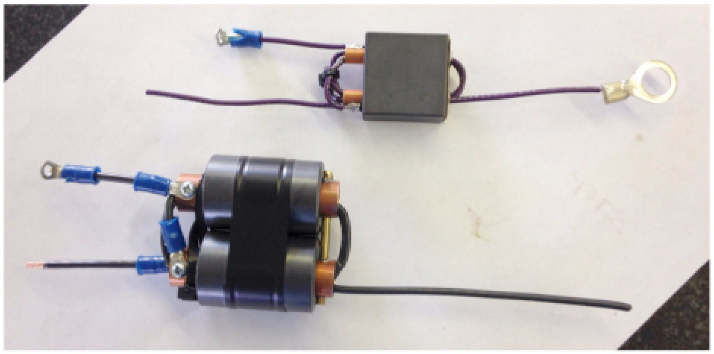
"Chameleon Antenna" posted:-

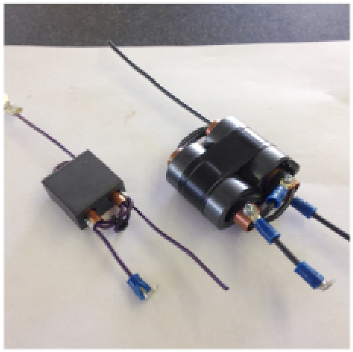
"Wow!! They're now using what we've been using in our HYBRID, HYBRID-MINI and EMCOMM II for years!!!! It's a 5:1 UNUN!! LOL"

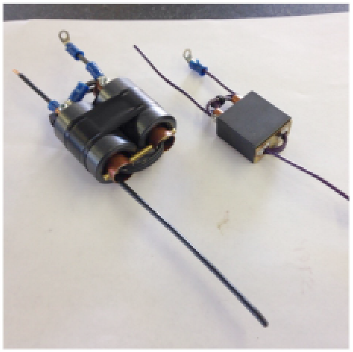
"ChameleonWalker" later posted:-

"This is the pictures of our 5:1 transformers.

https://www.dropbox.com/sc/3dfx1137sbu3jmc/AACt-xhgYo-DF9BgOhDV67wla







The larger one is used in the HYBRID, HYBRID-MINI, EMCOMM II, TD, TD Lite and the WINDOM 40 and the small one is used in the HYBRID-MICRO.

It took few days to get the pictures done because we were entirely sold out on just about everything! We're currently manufacturing 200 HYBRID, HYBRID-MINI and HYBRID-MICRO and tonnes of others products...

With any of the above mentioned antennas and with a proper installation this is the type of performances that can be possible to achieve with them. Our transformers are made in a way to reduce the losses to a minimum."

Here's a more detailed view of the larger transformer.

Here's another video that has been posted on Youtube. This one shows the inside of both an Alpha and Cameleon matching unit.

https://youtu.be/4n30XykCChY

They look very familiar don't they ?

Note that both Chameleon and Alpha Antenna get consistently good reviews on Eham http://www.eham.net/reviews/ so why not try building one yourself.

Other amateurs who have experimented with this concept are:-

Marty KN0CK

Giovanni IW2EN

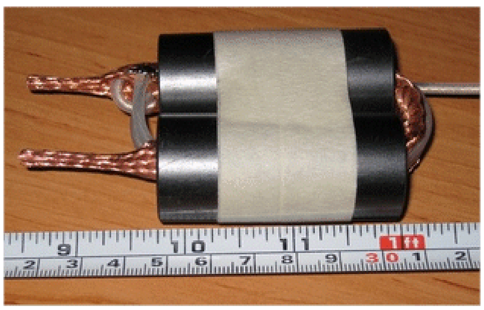
John. G4IJD

Jerry. G4GGZ

Peter, PE1DCD

Gernot, OE1IFM http://www.oe1ifm.at/index.php?option=com_content&view=article&id=54&Itemid=59 Built for the V53ARC WSPR beacon

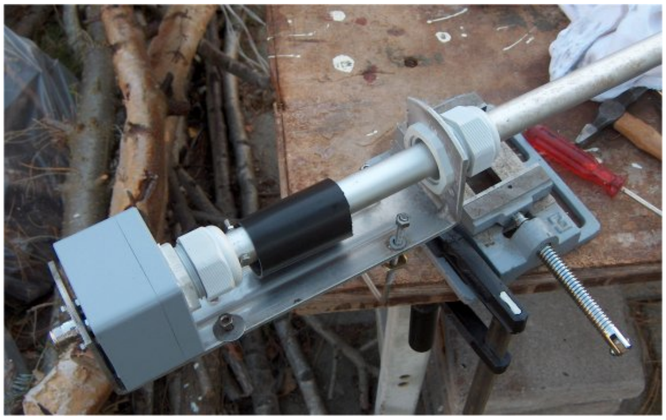
Wolfgang, OE1MWW



Dirk, PE1CZW

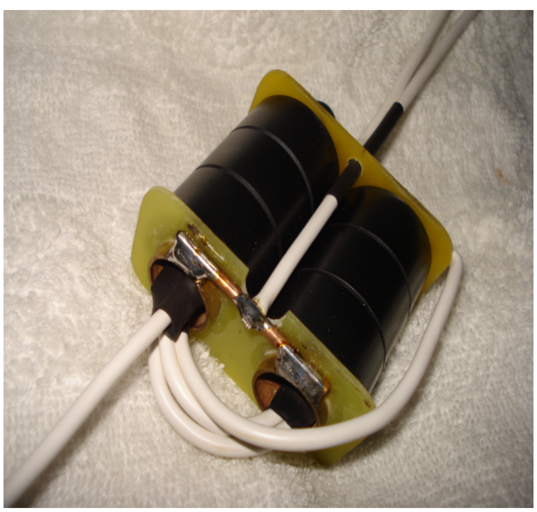
 

Sven, OZ6SI



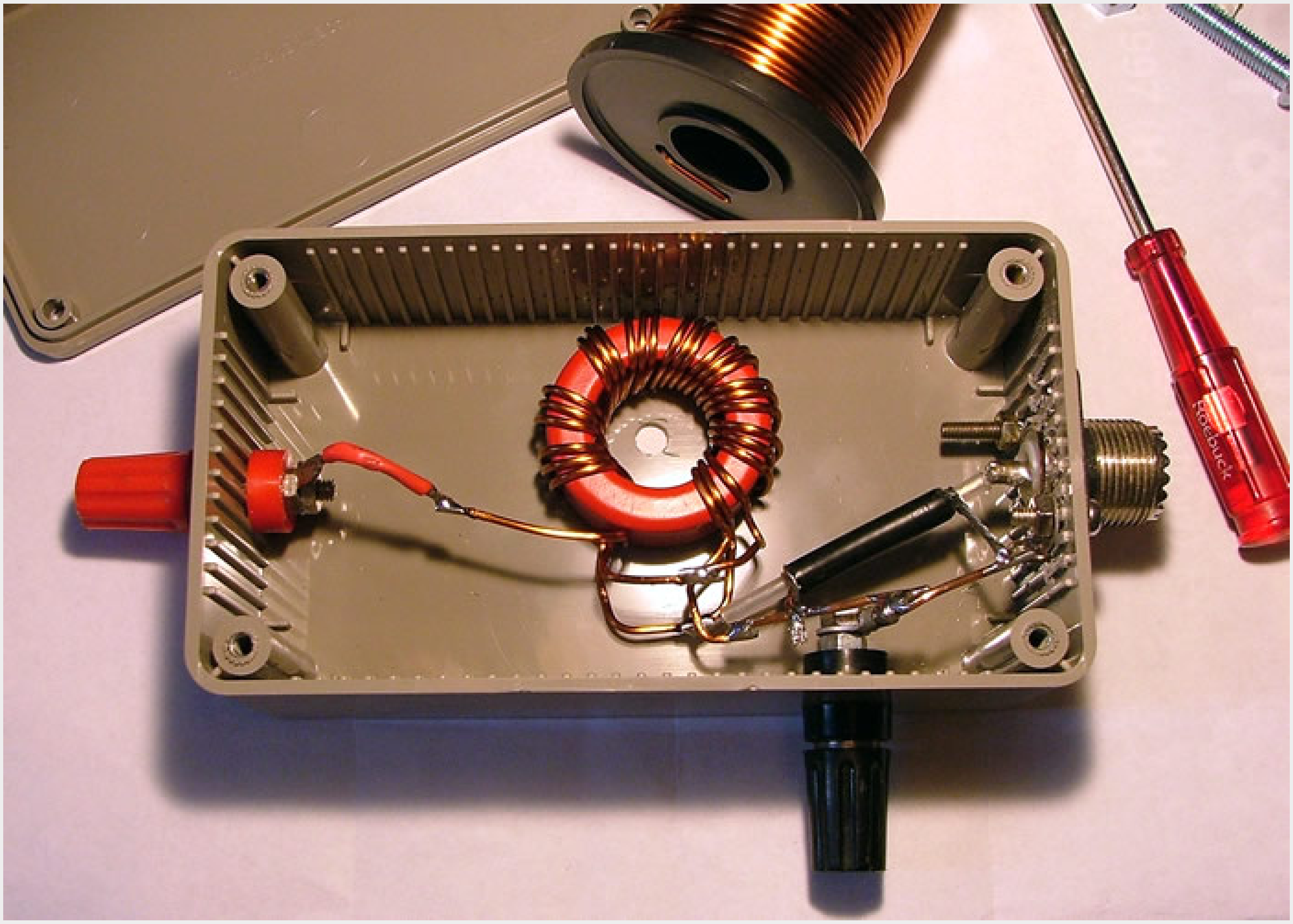
RAFAEL DE SOUZA

Miguel, PU3XPG



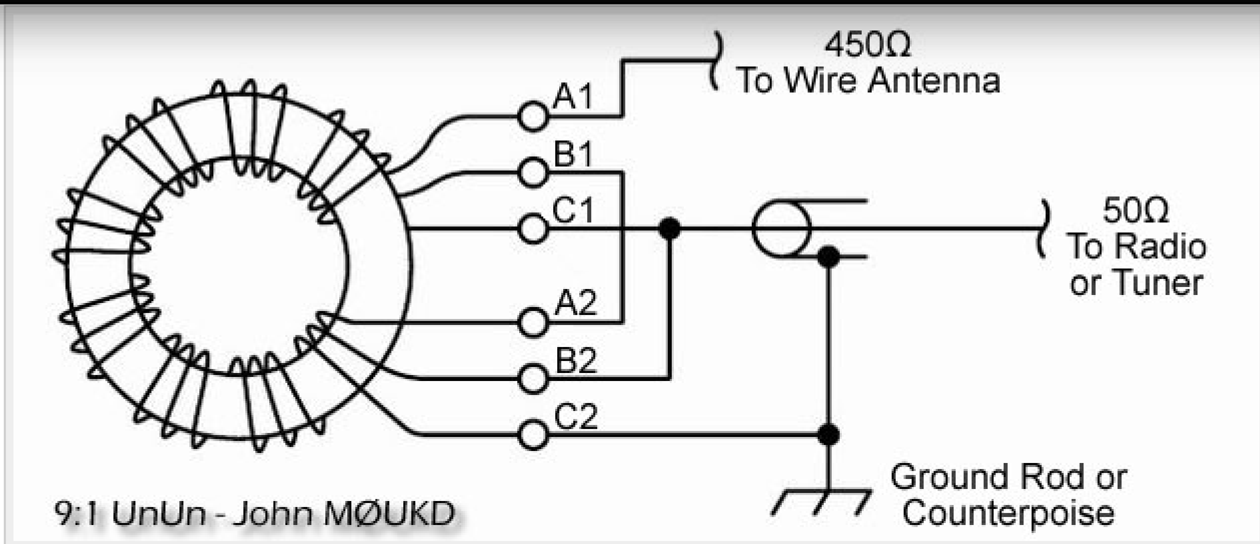
G8JNJ - Last updated 22/07/2016 v4.6

9:1 Magnetic Longwire Balun / Unun

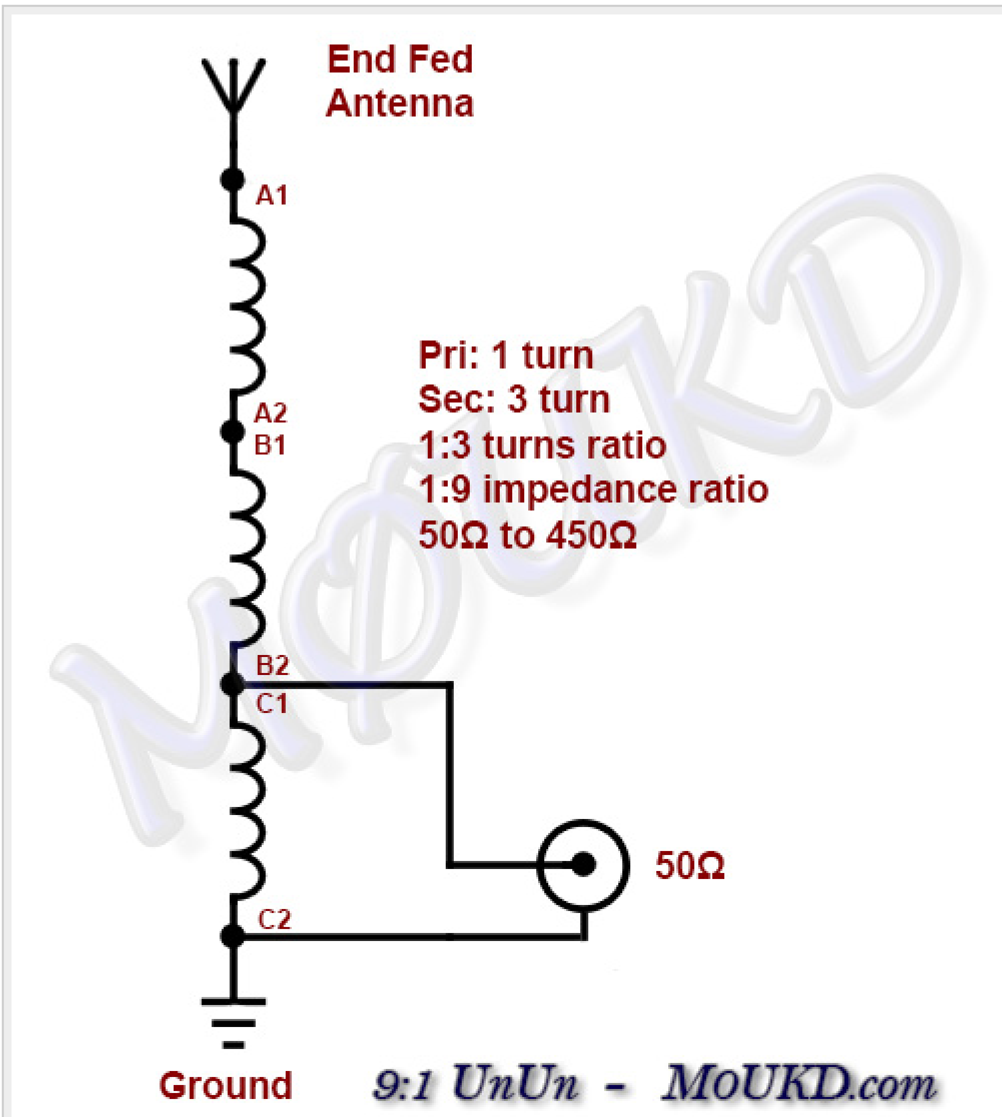


Completed 9:1 UnUn

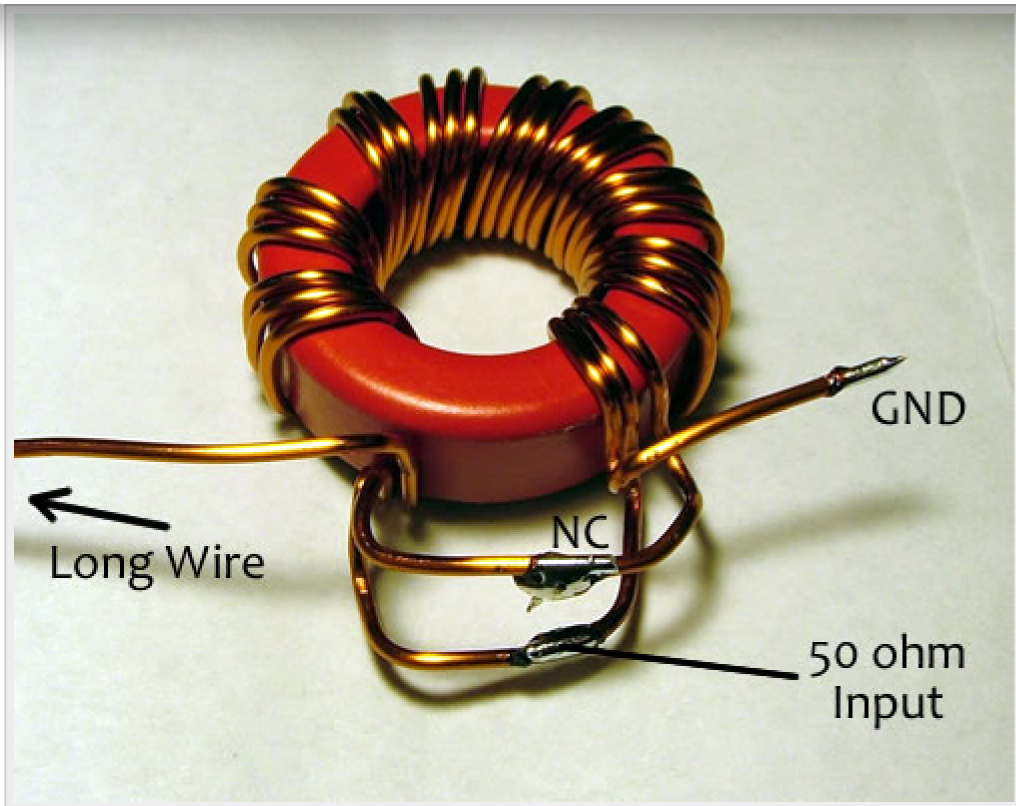
These are sometimes known as a *Magnetic Longwire Balun*. Its really an impedance transformer (9:1) to feed a high impedance, end fed (unbalanced) random wire which is likely to be a few hundred ohms, and transform it into something closer to a 50Ω (unbalanced) coaxial input, hence UnUn. It can however also be used as a balun by not grounding the other half of the balanced output. The toroid is a T130-2 Iron Powder core, with 3 x 9 turns of 18SWG enammeled copper wire, and the connections can be seen below.



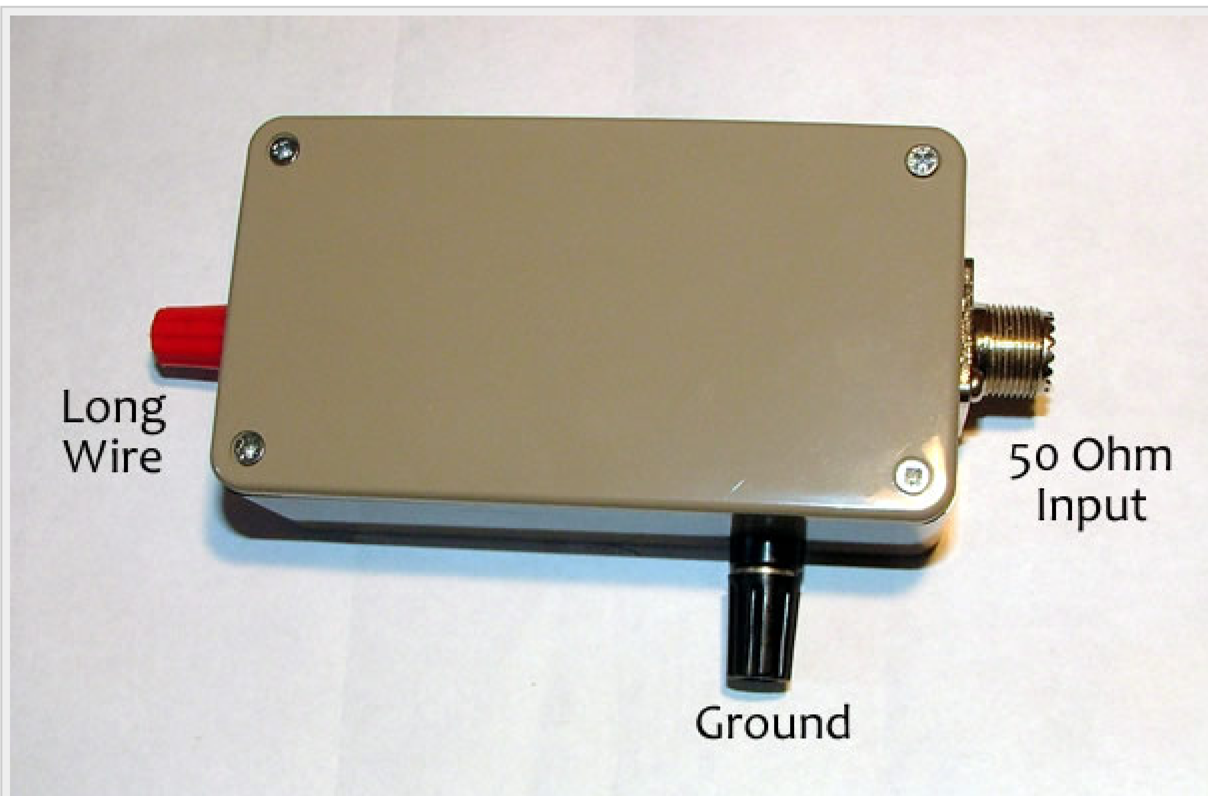
The triple winding connections. 8 turns is shown here, but more turns is preferred. 10 would be ideal.



9:1 UnUn Schematic



Completed windings



The completed unit.

QRPproject
Where power and intelligence unite

DL-QRP-AG

Lambda/2 no Counterpoise: Fuchs Antenna matching unit

Handbucherstellung: **FIservice** Peter Zenker DL2FI email:dl2fi@QRPproject.de Handbuch Version 2.0

The Fuchs Antenna was introduced by Arwed Fuchs, an Austrian Radio Amateur in 1928. It was used as a high efficiency single band half-wave endfed antenna by many radio amateurs over a long period, but it was more or less forgotten when most radio amateurs started using coax-fed dipoles. In the 80s, some Swiss OMs rediscovered the Fuchs Antenna Tuner, especially for portable use. In 2000, Frank, DL7AQT, did lots of experiments with the Fuchs, and was happy to end up with a multiband version for portable use. QRPproject is now proud to make the Fuchs Antenna Tuner available as a kit. It is based on Franks' design with some small modifications we made because the variable used by Frank is no longer available.

The QRPproject Multiband Fuchs

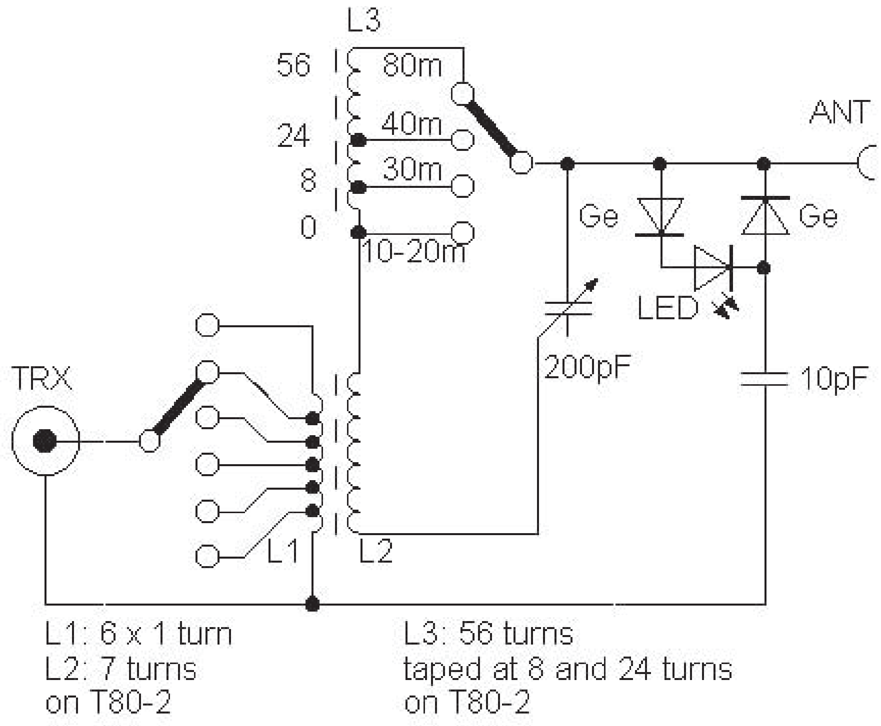
is basically a half wave antenna. It can be used with good results at the original frequency and also at all harmonics. It is fed by a parallel circuit with inductive coupling. Tables 1 and 2 show the optimal length of a wire from 1 half-wave at 80m to 8 half-waves at 10m. As you can see, the length increases from 80 to 10m. This is because the velocity factor of 0.96 is only exact at the ends of a wire antenna. If a wire antenna is longer then 1 half-wave, the middle part must be calculated using a velocity factor of 1. In practical use, we found that the Fuchs circuit easily compensates for this difference. When the total length is a multiple of a halfwave +/- 5 %, we found no difference. As you can see, a wire length of about 21 meters makes a good antenna for 40m and higher.

Tabelle 1

Frequenz (MHz)	Halbwellen	Drahtlänge (m)
3,55	1	40,14
7,025	2	41,64
10,125	3	43,70
14,05	4	42,17
18,08	5	41,07
21,05	6	42,40
24,9	7	41,87
28,05	8	42,51

QRG	Lambda/2	Drahtlänge
7	1	20,28
14	2	20,82
21	3	21,02
28	4	21,12

During his experiments, Frank used two different designs. For the upper bands only, it was ok to use one Amidon T80-2, but this design



did not work if he tried to use it from 80 to 10 meters. Some tests in the QRPproject lab using our HP Network analyzer showed that there are some extra points of resonance in the 18 MHz range. We assume that they are caused by the unused section of the core in interaction with stray capacitance. Winding the complete Fuchs circuit on TWO toroids solved the problem. There are still unwanted resonance frequencies, but they now are in the 60 MHz range, and without any influence when we tune a SW antenna.

Due to a lot of questions:

NO, there is now ground connection missing at L2!! This is part of the genious Fuchs design :-)

LED RF Indicator

The simple LED RF indicator detects the voltage at the feedpoint of the

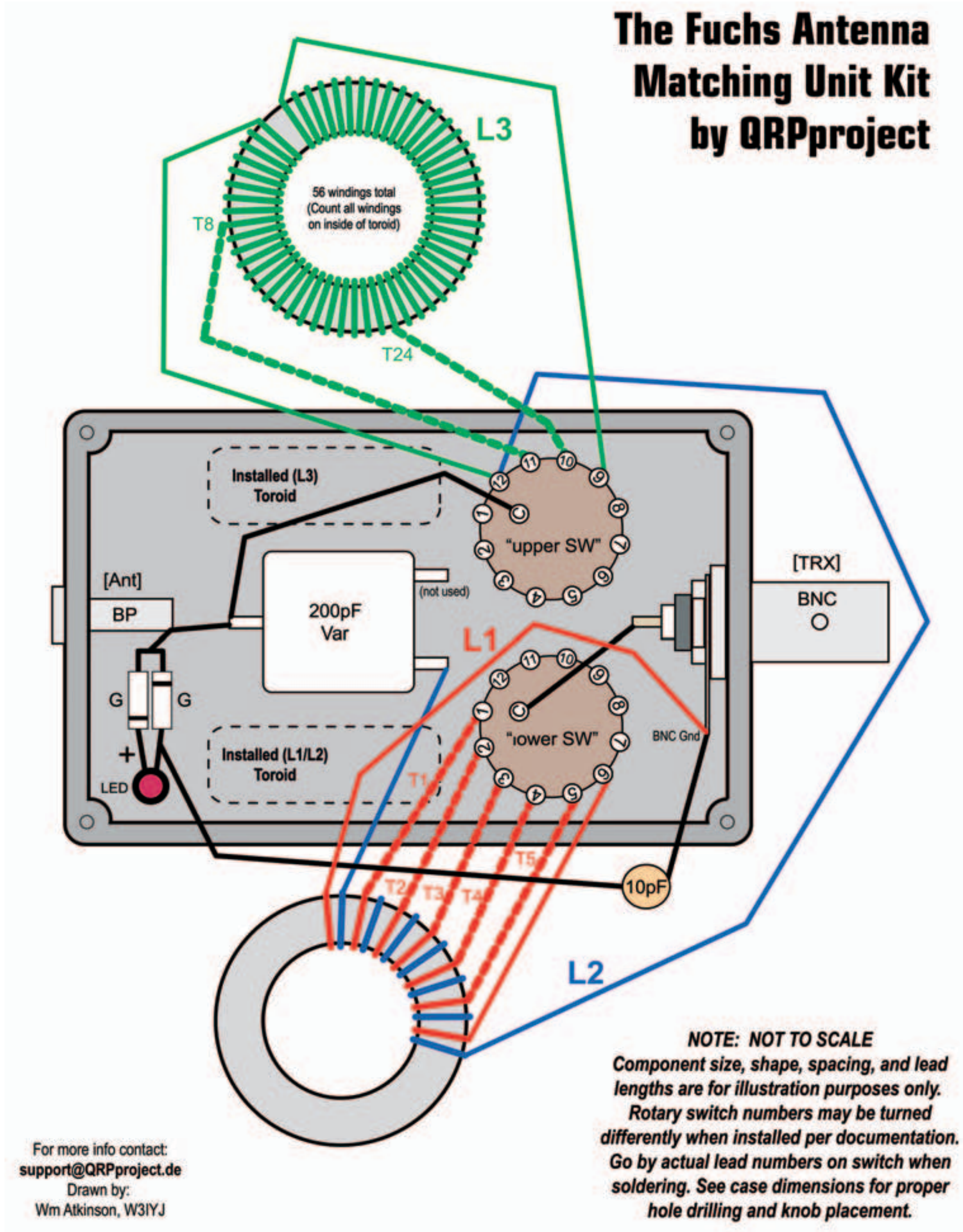
antenna. While tuning the Fuchs circuit, when the RF voltage at this point has its highest value, the antenna is exactly in resonance, and antenna coupling of the transmitter is at its optimum.

Practical experience

The Fuchs circuit was built into a 70mm x 50mm x 25 mm plastic enclosure. We used a BNC jack for the transceiver input and a banana jack for the antenna connection. It is very easy to tune. The first step is to tune the variable capacitor to loudest noise or signal in receive mode. You must switch the main coil taps to get the best result. The point of resonance is very small, so you will hear the difference between resonance and non-resonance very clearly. Usually you will find resonance at two different taps of the main coil. If so, use the one with the better L/C ratio (more L = higher Q). Now hit the transmit key in CW or a tune knob to get a transmit signal. Switch the coupling section of the Fuchs circuit to get the brightest signal at the LED RF Detector (or lowest SWR if your transmitter has a built in SWR Meter).

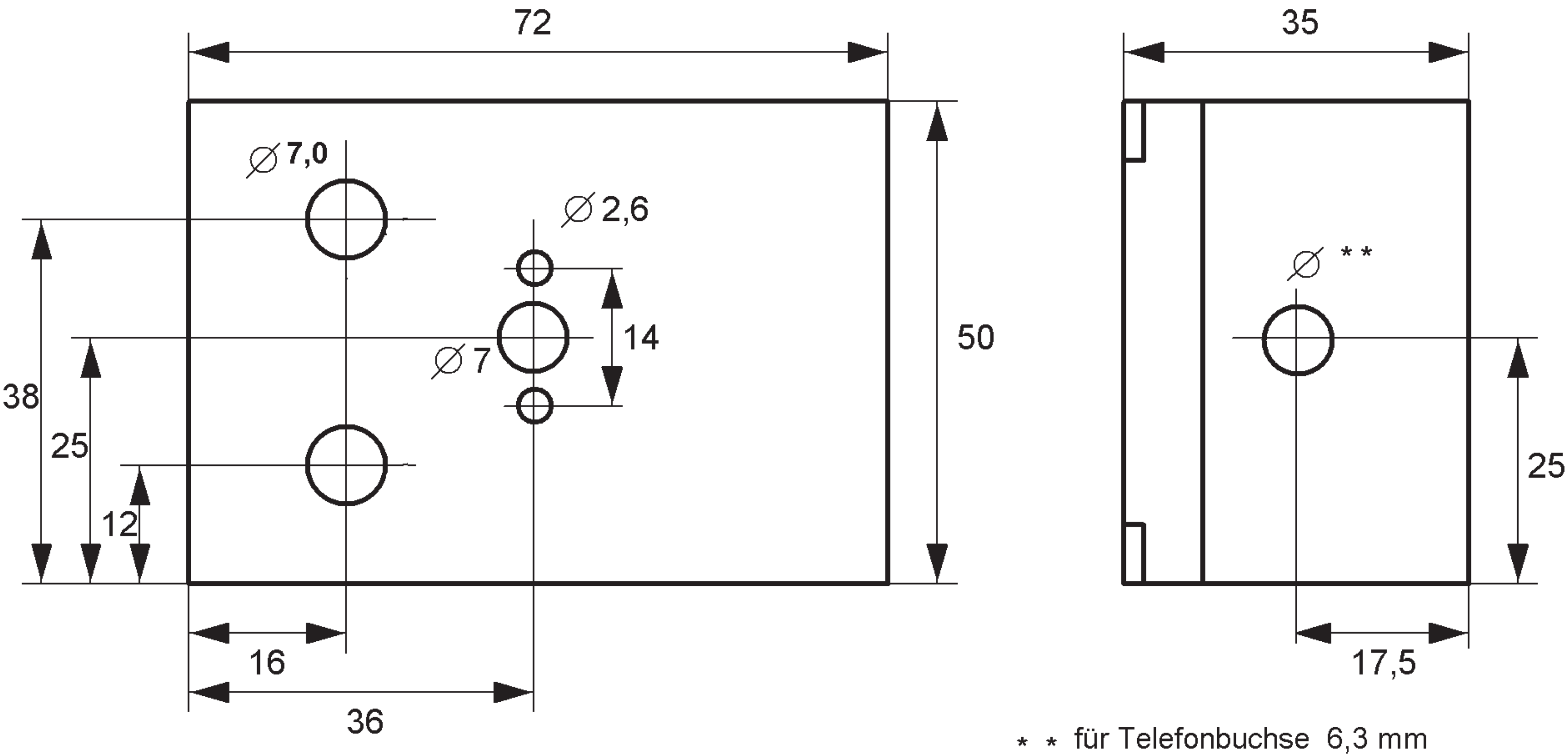
Parts list of the QRPproject 80-10-FUCHS kit

1 enclosure
1 variable cap
2 Amidon Toroid T80-2
2 Miniature switch 1x12
1 Banana jack
1 BNC jack
2 Germanium Diode
1 LED
3 Knobs
Enameled wire 0,5mm
Ceramic capacitor 10pF
1 manual



Attention: starting July 2008 we use another type of switch. It´s smaller and the common conector is placed exactly in the middle of the switch.

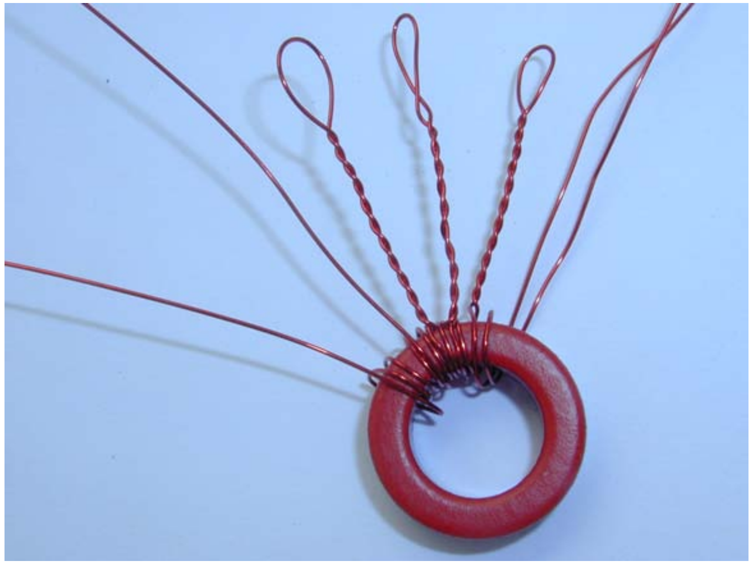
†1. Preparing the enclosure
Drill all holes as shown in the drawing. All distances refer to the outer side of the enclosure. The diameter of the holes are taken from the diameter of the provided parts. The BNC jack and the Banana jack



* * für Telefonbuchse 6,3 mm

* * für BNC-Buchse 8,5 mm

must be placed exactly in the middle of the front and back (short) sides, as shown on the pictures.



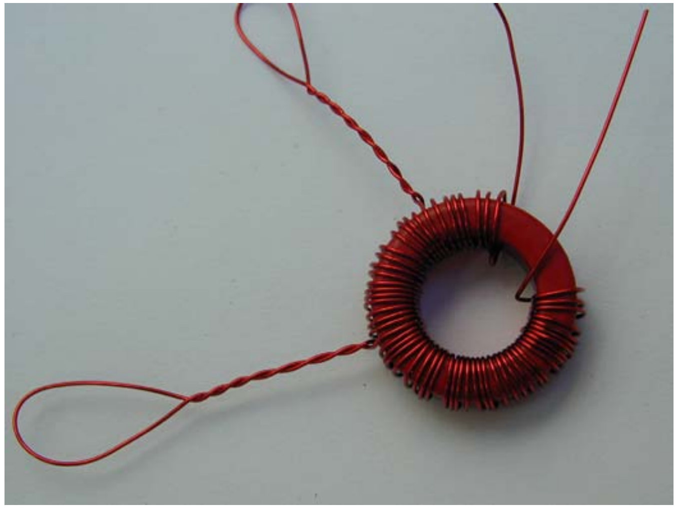
2. Winding the Toroids

L2/L1

Attentention, the pictures do not show the exact number of turns.

Remember that turns on a toroid are always counted at the inner side of the ring. Start with 7 Turns for L2. Don't spread the 7 turns over the ring, but keep the turns close together at the inner side of the ring. Leave about 6cm at both ends of L1. Now, wind L1 (the coupling winding) between L2. For these to be in phase, lay the wire for L1 parallel to the L2 wire and start at the same point, where L2 starts. Do one turn through the Ring, and then form a loop (abt 3cm diameter) and twist the loop as shown in the photo. (ATTENTION, photo does not show all windings) Do the next five turns, forming such a loop after every turn.

To see how long the twisted loops must be, put the toroid at its place just below the lower 1x2 switch (BNC right sided, banana left sided, as shown in the photo). Bend all wires to their places, and cut them to the desired length. The beginning of L2 goes to the stator of the variable cap, end of L2 to the Pin 12 of the upper rotary switch. The starting point of L1 goes to BNC Ground, first tap to Pin 1 of the lower rotary switch, second tap to pin 2, third tap to pin 3, and so on; all taps and the end of L1 to the lower rotary switch. Next step is to tin all the wire ends. We prefere the „BLOB" method. What is the BLOB method? Using a hot soldering iron, melt a drop of solder at the end of the tip and hold it to the wire you would like to tin. Wait until the coating of the wire starts melting. You will see and smell some smoke. Don't breathe the smoke; it's not very healthy! When the coating starts melting, move the solder „BLOB" back and forth. The result will be a nice tin coating at the end of the wire. Check to see if the tin is all around the wire. If not, do the same procedure again. When all the ends and taps are tinned, solder L1/L2 to the 1st place, as described.



Next prepare L3

Take the other T80-2 toroid. Wind 8 turns and form a 4-5cm loop as you did for L1. Wind the next 16 turns in the same direction, giving you a total of 24 and form a second loop. Now, wind another 32 turns(total of 56) Now, place the toroid above the upper rotary switch, and prepare the wires. The beginning of L3 leads to Pin 12 (junction to L1), the first tap (turn 8) leads to Pin 11, second tap (Turn 32) to PIN 10, and the end of L3 to pin 9. Again, coat the wire ends with Tin, and solder them to their places.

3. solder all remaining solder-points:
Solder a wire between the middle pin of the lower rotary switch to the inner pin of the BNC jack. Solder another wire between the middle pin of the upper rotary switch to the rotor of the variable capacitor, and another short wire from the rotor to the banana jack. The only remaining thing now is the LED RF-Indicator.

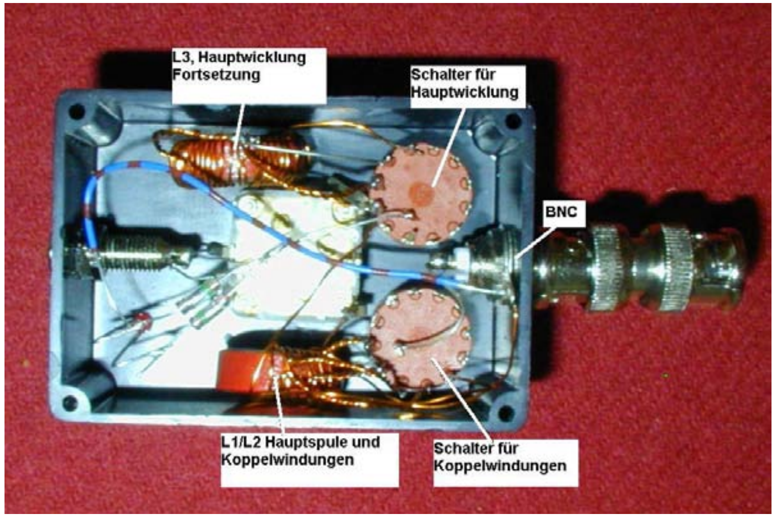
Drill a hole for the LED somewhere in the top of the box, near the banana jack. Solder the cathode of one germanium diode and the cathode of the other Ge diode to the banana jack. The other side of both diodes must be soldered to the LED: (Ge-cathode to LED anode, and Ge-anode to LED cathode.) The cathode of the LED must be connected to BNC ground using a piece of wire and the 10pF ceramic cap.

That's all! The Fuchs circuit is now ready to use.
Remark:
By practical use we found that the Diodes plus the LED may cause intermodulation to your RX especially at winter evenings at 40m when using long antennas. If you run into this problem, remove the 10pF cap connected between the LED and ground. The LED will still work as an indicator, picking up energy by stray capacitance. It will not glow as strong as before but still enough to work as an indicator. Give it a try.

Start operating:

Connect the Fuchs using the BNC:BNC connector to your transceiver. Use a 41meter (or 21 meter) long antenna wire, connect it to the banana jack,and switch the receiver on.
At first, choose the coupling factor by switching the lower rotary switch. For 10 and 12 meters, this will probably be 1 turn; for 15, 17 and 20M, 2-3 turns; for 30 and 40M, 3-4 turns; and for 80M, 4-6 turns. Now adjust the main windings using the upper rotary switch and the variable cap. Start with the switch at its lowest position and rotate the variable cap. If you have chosen the right tap of the main winding, you will find a dramatic increase of noise if the capacitor has the right value to resonate. If there is no point of resonance, try the next tap. If the circuit is in resonance, key the transmitter and adjust the coupling for best SWR (brightest LED).
This procedure seems to be complicated, but you will find, that it is very reproducible. So, in the future, you only have to remember which tap to use for which band, and tuning will be very fast. I hope you will enjoy your Fuchs antenna tuner! It's an excellent choice for portable use, because you will need only one port, and because it is a high efficiency tuner with very low loss.

Peter, DL2FI
If you have any questions or suggestions, please send me an e-mail, or phone: Support@QRPproject.de / +49 30 859 61 323



The Multiband FUCHS
by DL7AQT, Frank

The FUCHS Antenna got its name from the Austrian Radio Amateur FUCHS, who first described it in 1928. It was a monoband endfed half wave dipole.

The length of the antenna wire should be a Lambda/2 or a multiple of it. For 3,5 MHz you need about 41 meters.

With the FUCHS Network it is possible to use a 41 meter wire on all bands between 10m and 80m.

Tabelle 1

Frequenz (MHz)	Halbwellen	Drahtlänge (m)
3,55	1	40,14
7,025	2	41,64
10,125	3	43,70
14,05	4	42,17
18,08	5	41,07
21,05	6	42,40
24,9	7	41,87
28,05	8	42,51

Table 1 shows the length of wire we need for a given number of half wavelengths per band.

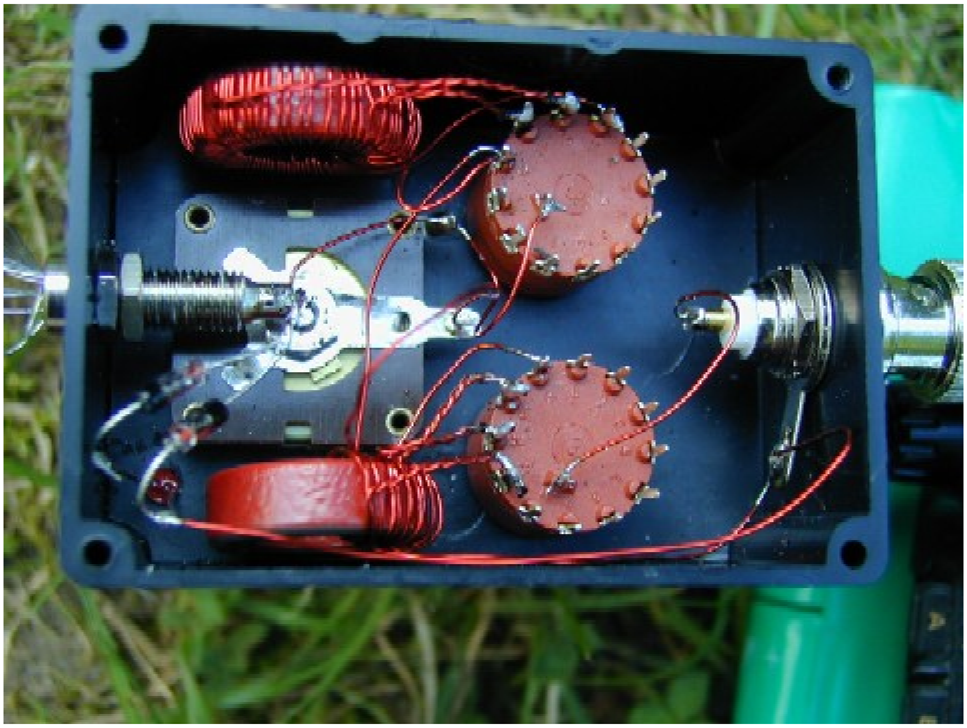
For 10m through 40m use a 21m wire.
For 10m through 80m use a 41m wire.

The QRPproject FUCHS Antenna

The network fits into a 70mm x 50mm x 25mm plastic enclosure. A BNC plug plus a BNC to BNC connector gives use the flexibility to use it with any rig which has a BNC antenna jack. Tuning is very easy. The first step is, to find the point of maximum noise / loudest signal in receive. Now with a small transmitter signal, the link is switched to lowest SWR. Ready.
The FUCHS is equipped with an output indicator. Only at the point of resonance does the LED glow.

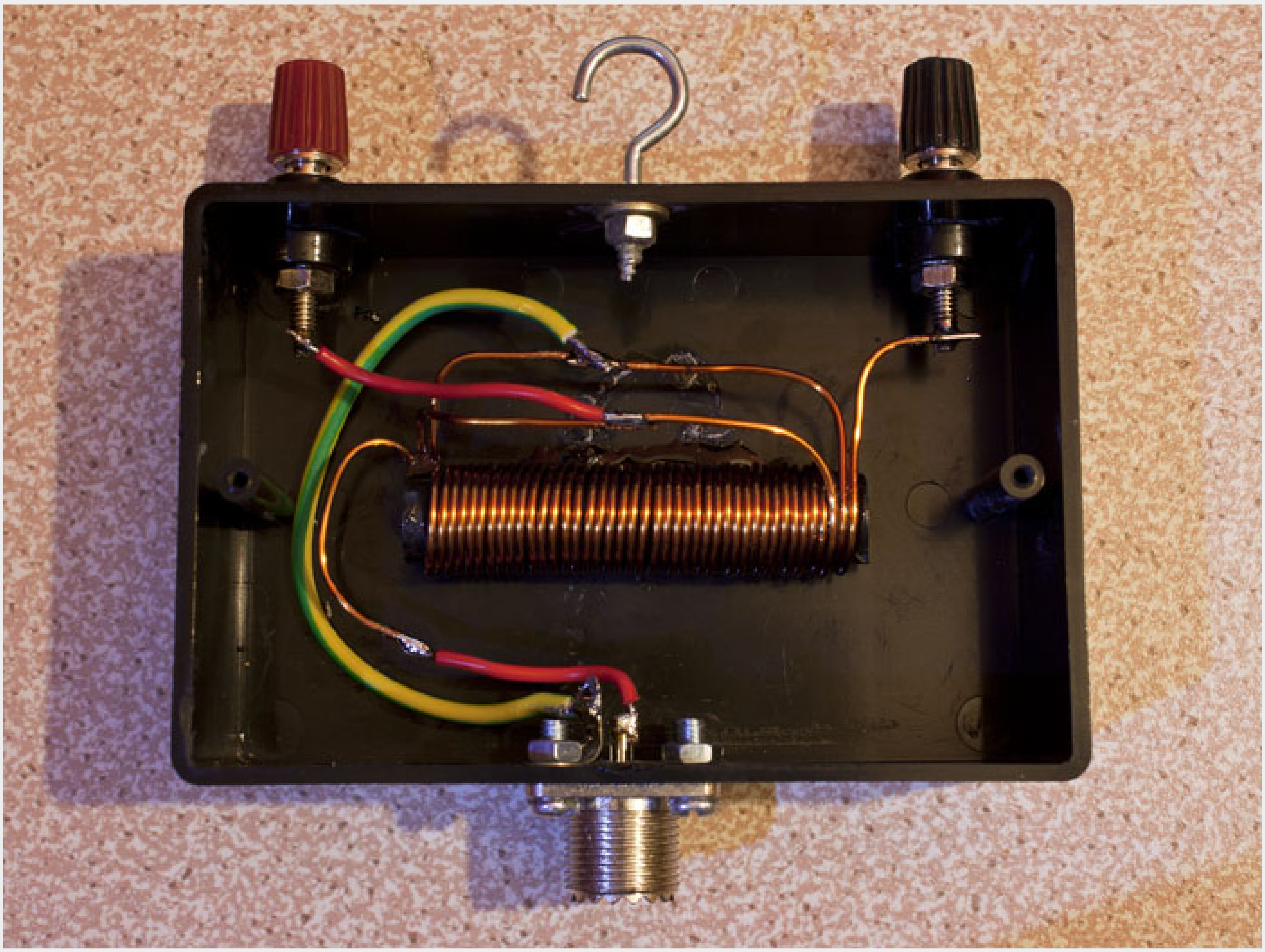
Parts list of the QRPproject Fuchs 80-10 kit
1 Enclosure
1 Variable capacitor (Poly Varicon) 340 pF
2 Amidon Torroid T80-2
2 Miniature 1x12 switch
1 Banana jack
1 BNC jack
2 GermaniumDiode (1N34)
1 LED
3 Knobs
3m enameled wire (24 AWG)
1 BNC<> BNC connector

The Multiband FUCHS Antenna Tuner

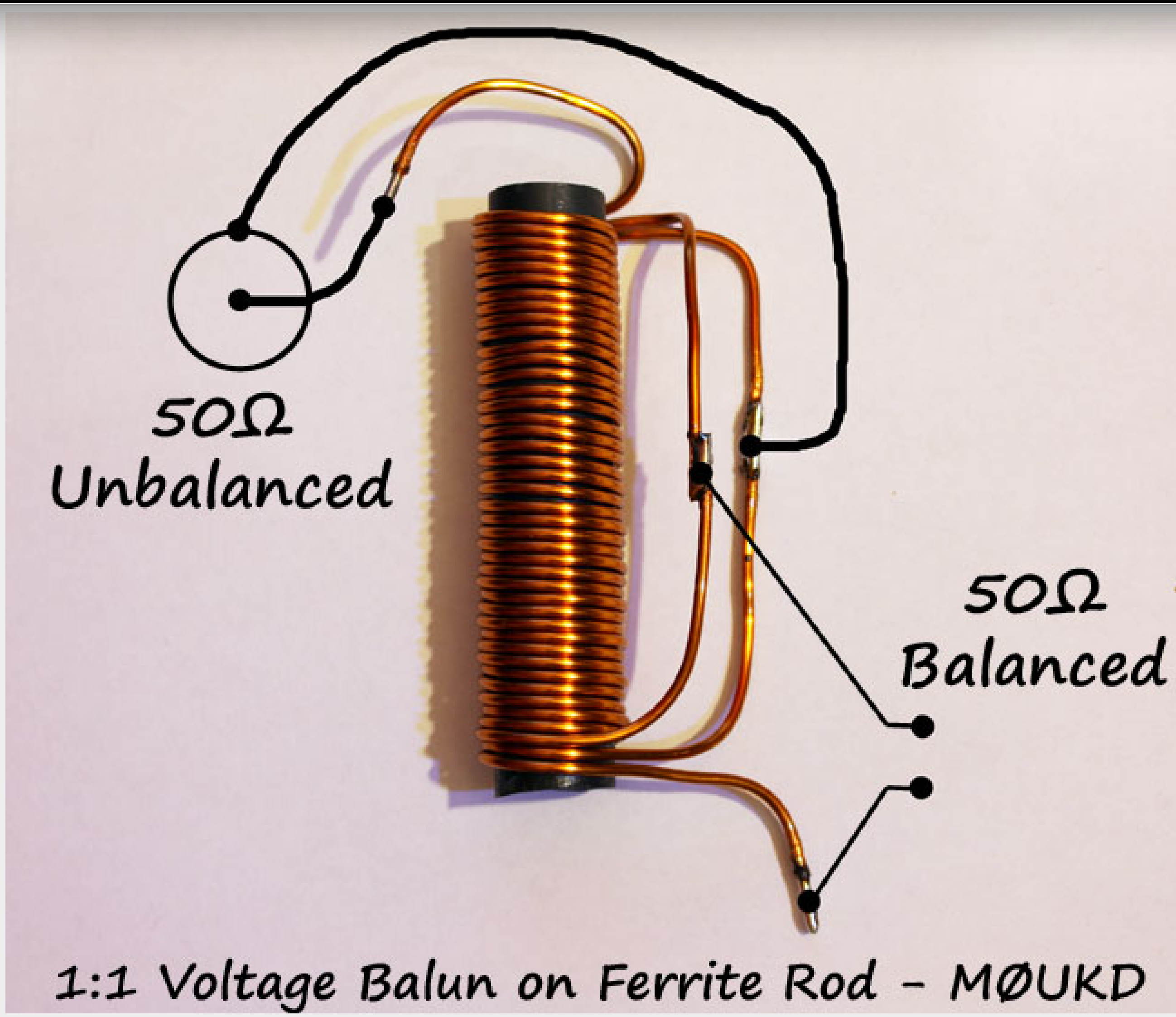


1:1 Voltage Balun for HF wire dipoles

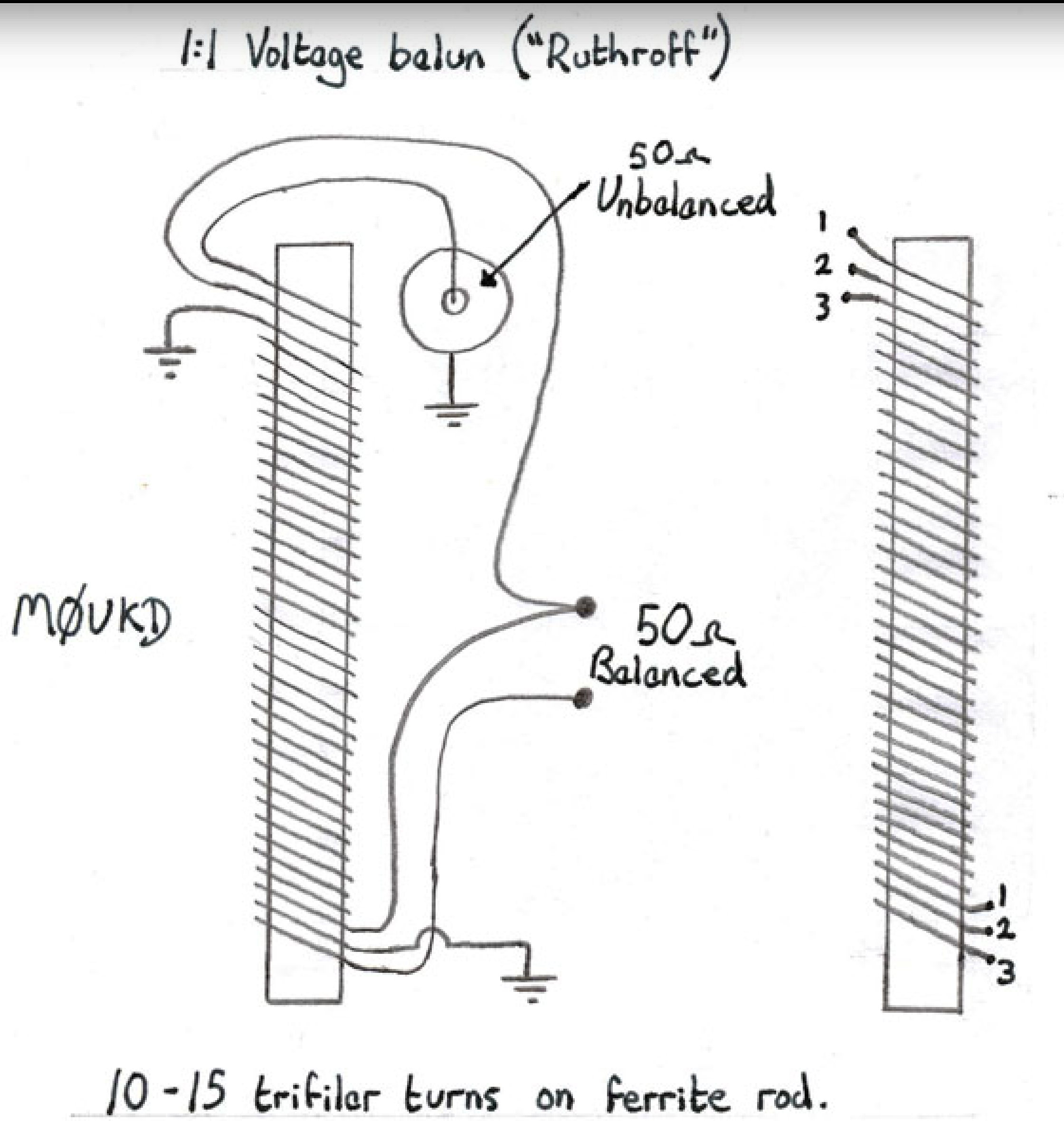
Heres a neat 1:1 50 ohm balun for use on HF horizontal wire dipoles. It uses an AM radio ferrite rod, with 3×14 turns of wire. 10-14 turns should be good for 2-30MHz. I used 18SWG enammeled copper wire. It all fits in a small project box. Great for setting up portable. For 20 metres, I started with 6 metres of wire per element, and trimmed each down until it has minimum S.W.R. I managed to get a 1:1.1 S.W.R. on my desired frequency. Bandwidth from the resonant frequency is about 200KHz either way, any more needs an ATU. The wire and ferrite core I had already, the box, terminal plugs and SO-239 came to about £6. The balun can also be built on a ferrite toroid such as an FT140-43 or FT240-43.

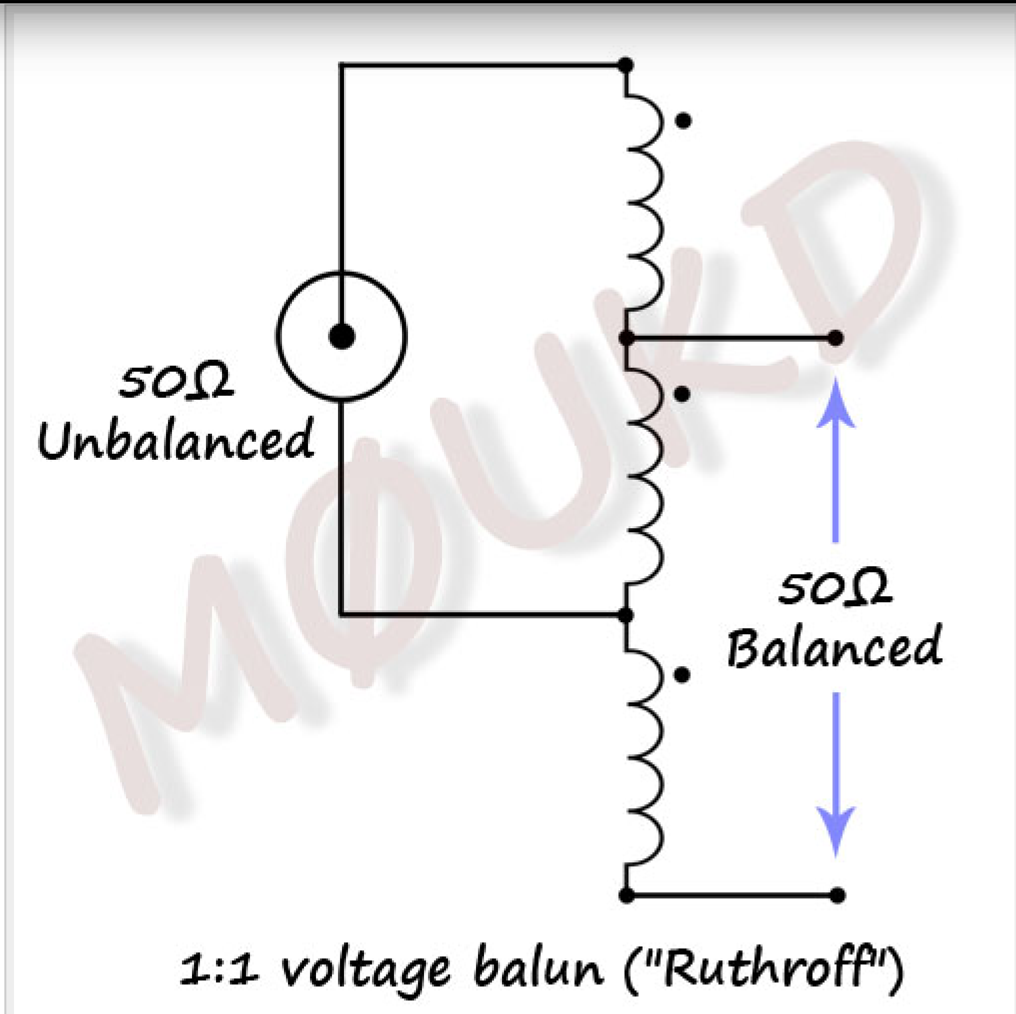


1:1 ferrite rod voltage balun

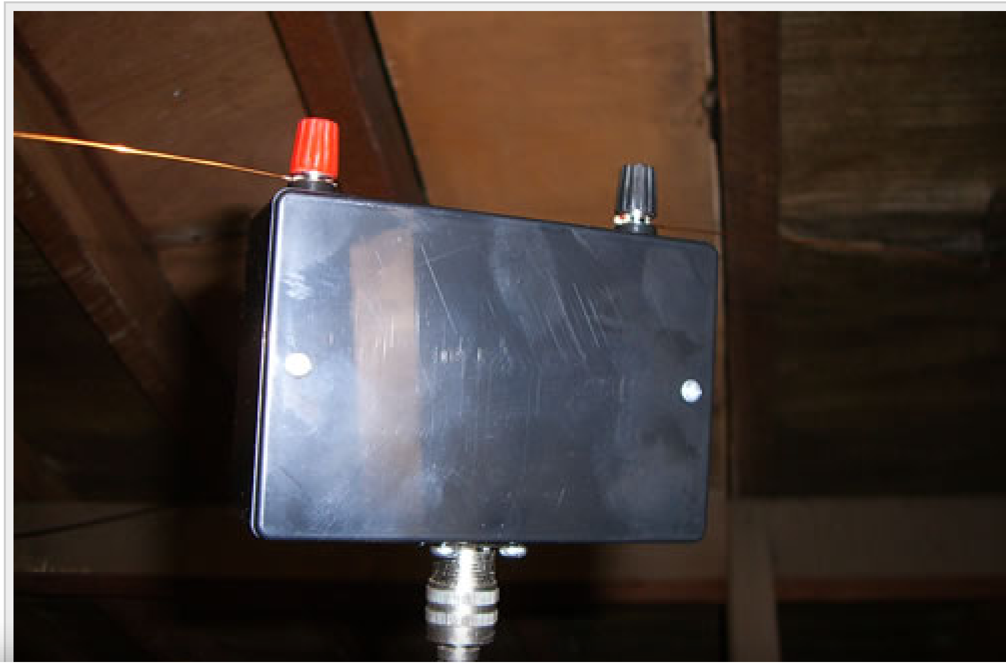


Bandwidth may be increased by more spacing between each trifilar turn. I didn't have room on this tiny ferrite rod, but it performs OK.

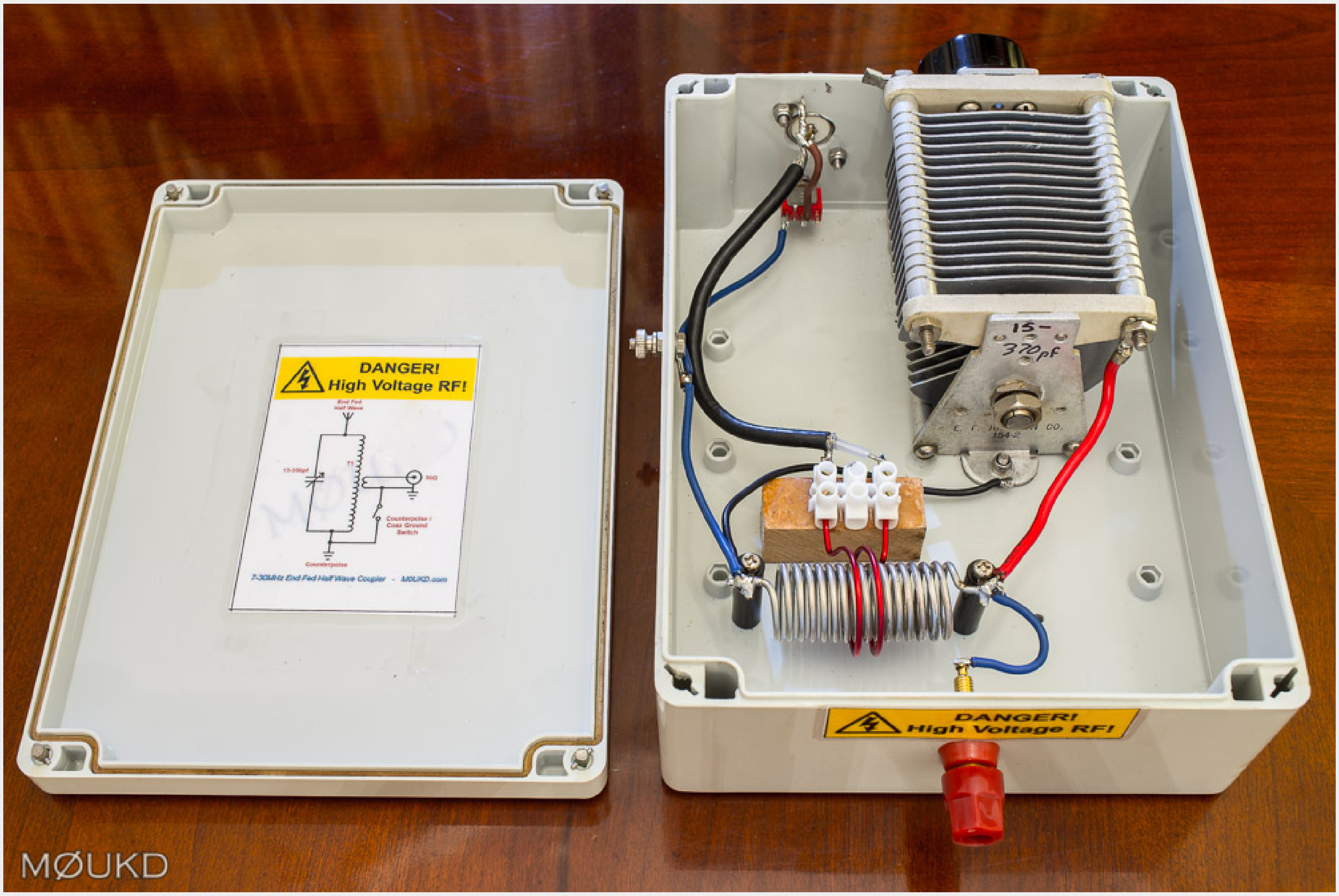

1:1 Voltage balun ("Ruthroff")
50Ω
Unbalanced
M∅UKD
50Ω
Balanced
1
2
3
1
2
3
10 - 15 trifiler turns on ferrite rod.



Schematic Diagram



End Fed Half Wave Antenna Coupler (EFHW)



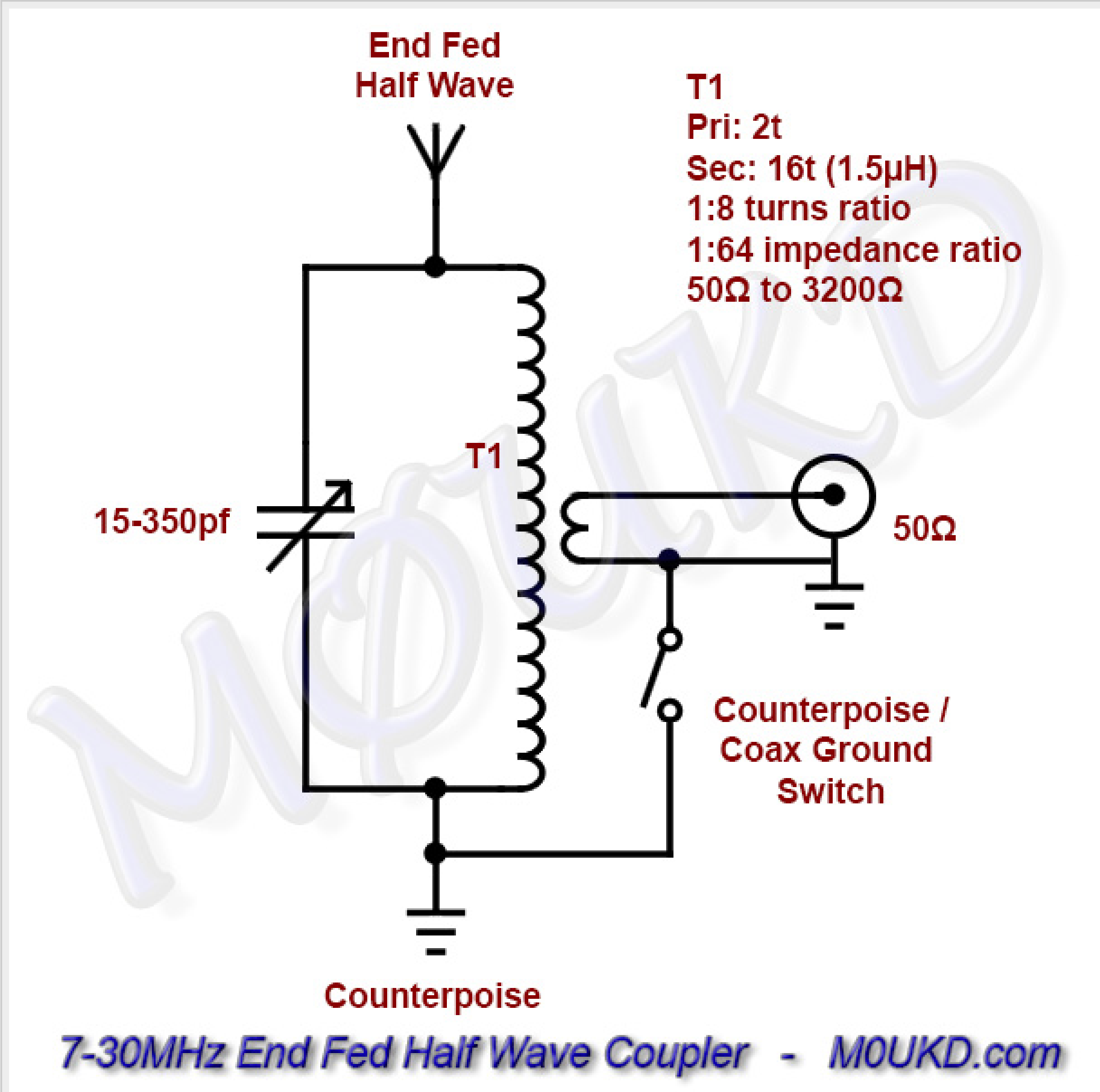
The finished End Fed Half Wave antenna coupler.

Centre fed half wave dipoles make great, simple and effective antennas for the HF bands. Sometimes however, the centre feed is not ideal, for example when you want to use it as a vertical. Being able to feed the dipole from one end gives you more options on how to erect an antenna and makes portable operation easier. A vertical, a sloper, a piece of wire hung in a hedge are all good examples. A ground mounted half wave vertical has a peak radiation angle of 20°, so it makes a good choice for DX.

I have been experimenting with feeding end fed half wave antennas matched by a parallel tuned circuit coupler. This article will explain my findings and reasons for constructing it the way I did.

A dipole can be fed anywhere along its length. A centre feed gives around 70Ω. A 'Windom' type off centre fed dipole (fed 38% along its length) provides around a 200Ω feed. The feed impedance at the very end of a half wave is thousands of ohms, usually somewhere between 2000Ω to 5000Ω, which we need to match to our 50Ω transceiver. The problem with end feeding a half wave is also its advantage. The high impedance means that the feedpoint has a very high voltage but low current, therefore very little ground is required. A very small counterpoise should be adequate from 7 to 30MHz, or you can even use the coax and transceiver

Below is the schematic of the final build.

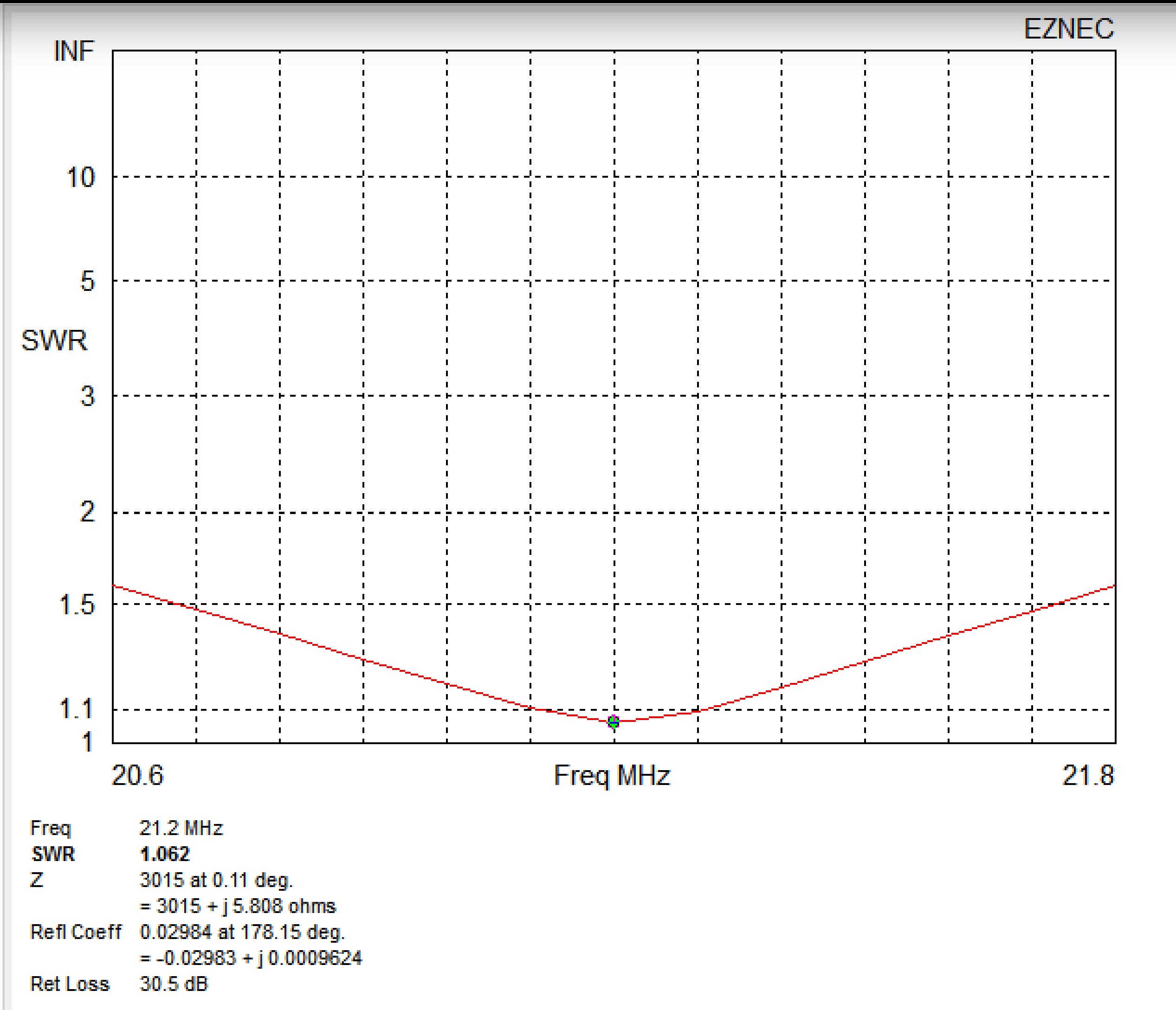


End Fed Half Wave Antenna Coupler Schematic – 7-30MHz

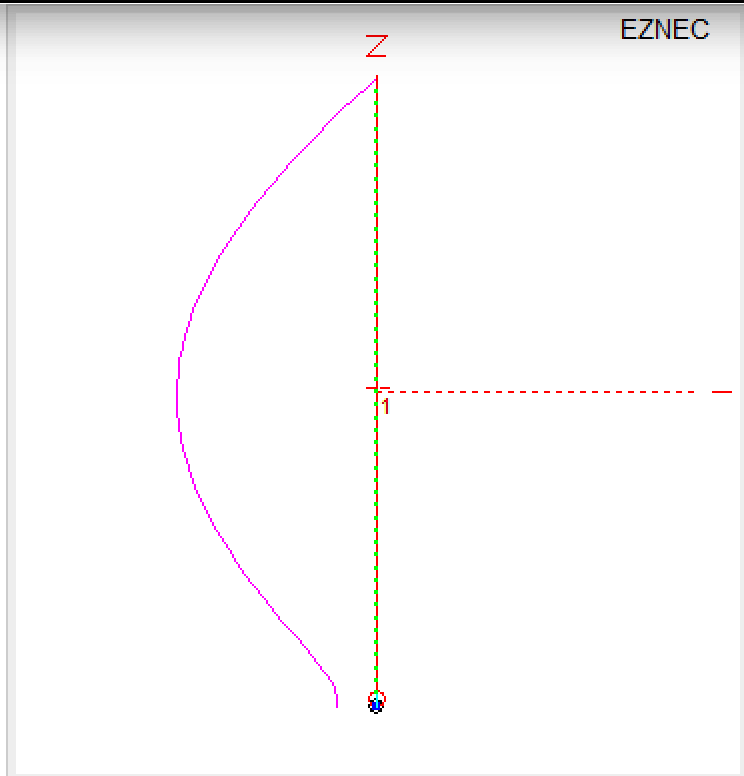
For calculating the length of a half wave in metres, I use 141÷*f* (MHz) for wire elements. These dimensions were derived from modelling the antenna in EZNEC. I have found this calculation to work well, however it depends on many factors such as wire used, location etc. I have made a javascript calculator below for simplicity with a 15m half wave ready to go!

Enter the frequency: 21.25 MHz

Calculate



End Fed Half Wave (6.65m @ 21.2MHz, ground mounted) SWR – Actual bandwidth on the 50Ω side of the coupler will be much narrower, due to the tuned circuit we are using. This is showing the feed point SWR at 3200Ω



Current along the half wave. Notice how the feedpoint is not quite as high impedance as the top of the antenna.

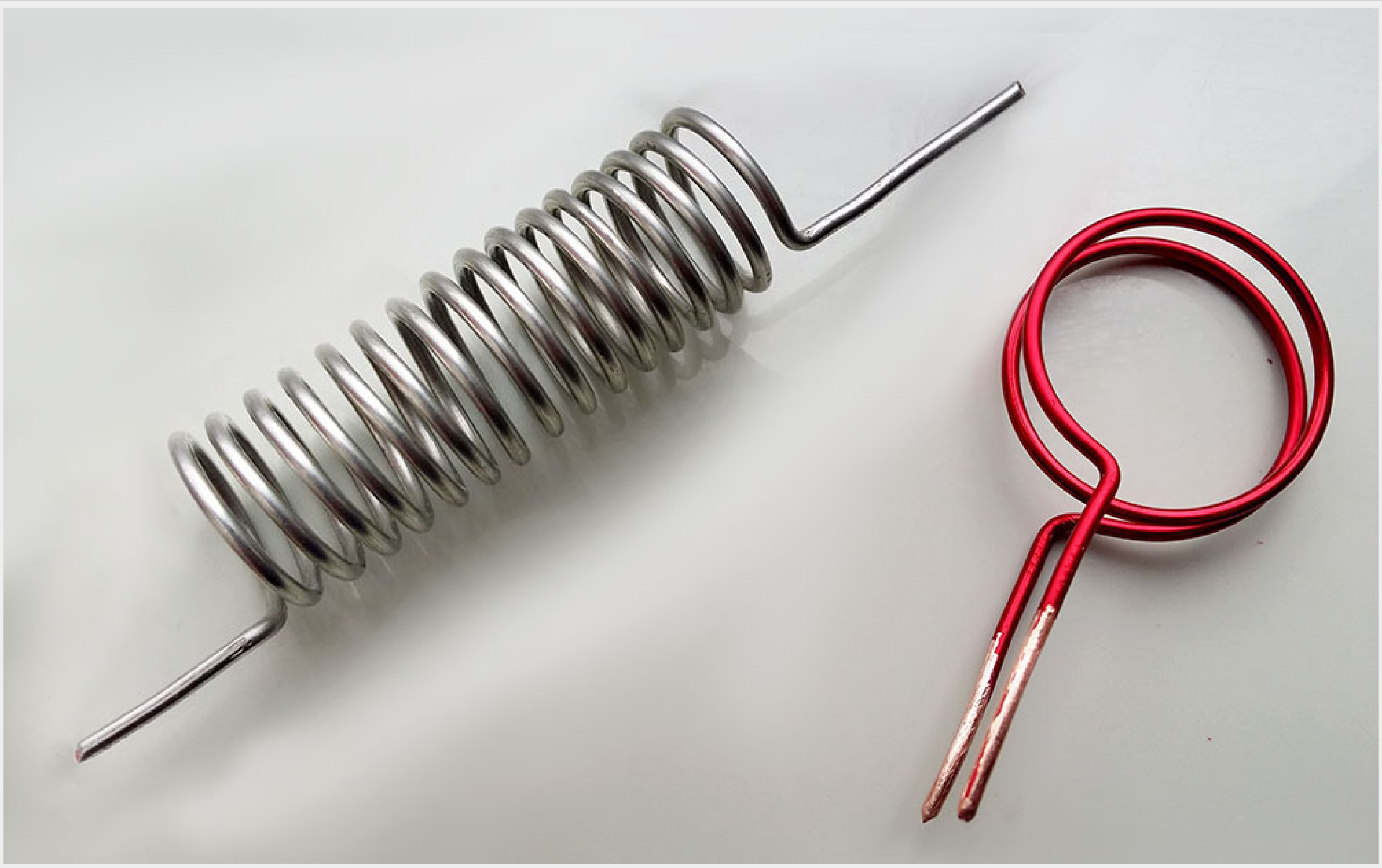
First off, construction will be a juggle between available components and the desired band coverage. I had a capacitor that I wanted to use, which is a Johnson 154-2 air variable capacitor, with a range of 15-353pf. I would like to cover 7 to 30MHz with my coupler if possibe, so the next thing I needed to design was an inductor that would resonate in a parallel LC circuit at just above 30MHz when the capacitor is at minimum. Using this **Resonant LC Calculator**, I worked out that an inductance of 1.5µH will resonate at about 33MHz when the capacitor is at 15pf and 6.9MHz when the capacitor is at its maximum of 353pf. Sounds perfect to me! If you have a smaller value capacitor, for example 200pf maximum, it should still cover 10MHZ to 30MHz. A switch could be added to add a further capacitance of 150-200pf to include 7MHz operation.

So, lets build the secondary transformer inductor first. I wanted to transform 50Ω to around 3000Ω. This would require a 1:8 turns ratio. Impedance transformation is calculated by squaring the secondary turns ratio (note ratio, not actual turns) 8^2 is 64. 50×64=3200Ω (our input impedance x 8^2). I looked at using a **T200-6** iron powder toroid, but the problem was 1.5µH required *only* 12 turns. As I wanted a 1:8 turns ratio (for a 1:64 impedance ratio), I needed a primary of 1.33 turns, which was going to be impossible. I could have made it 16 turns and a 2 turn primary, but then the inductance would be too large for 30MHz.

So, I decided to use an air wound transformer. This way, I can build it with a 16 turn secondary, *and* at the inductance I wanted by altering the diameter and/or length of the coil. Using this **Air Inductance Calculator**, I worked out that a 19mm diameter, 52mm long, 16 turn inductor should give an inductance of 1.5uH, so this is what I built.

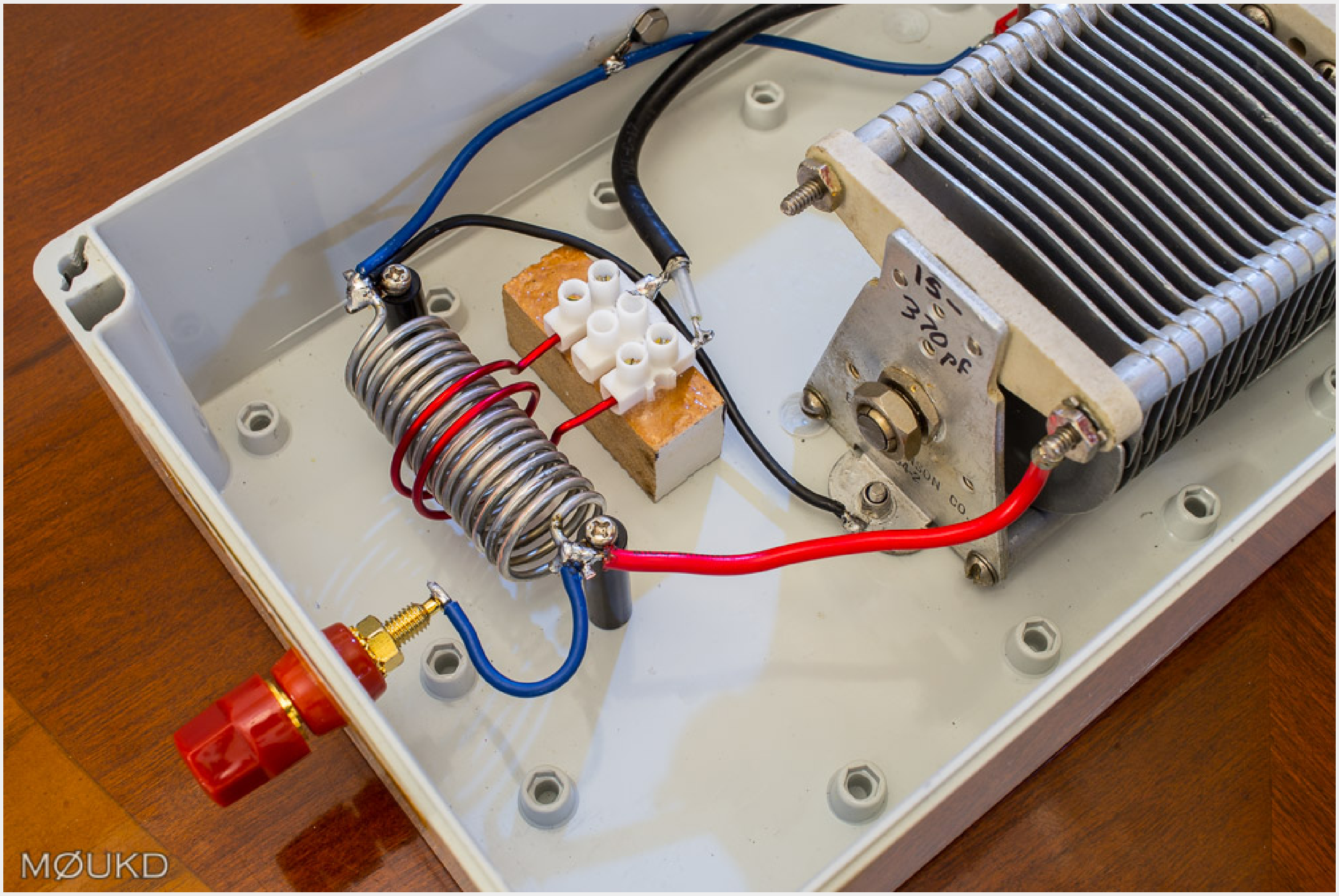
Winding the secondary inductor

Once it was wound, I tested it on an LC meter, which confirmed it was around 1.5µH. You can expand or contract the inductor to fine tune the impedance to suit. The importance is that it remains 16 turns to match with the 2 turn primary. I then wound the primary coil, which had to be a slightly larger diameter so that it could fit over the secondary coil and provide inductive coupling. You can see the finished 2 turn primary and 16 turn secondary below.



The completed inductors. They have their differences, but I will make them a happy 'couple'!

secondary and a terminal block glued to a small block of MDF for the primary. The coax is soldered to the primary, the terminal block is just to hold it in place. There is a counterpoise connection on the side, the antenna connection on the front and the capacitor, SO239 and counterpoise/coax ground switch on the rear. Some photos of the completed unit are below.



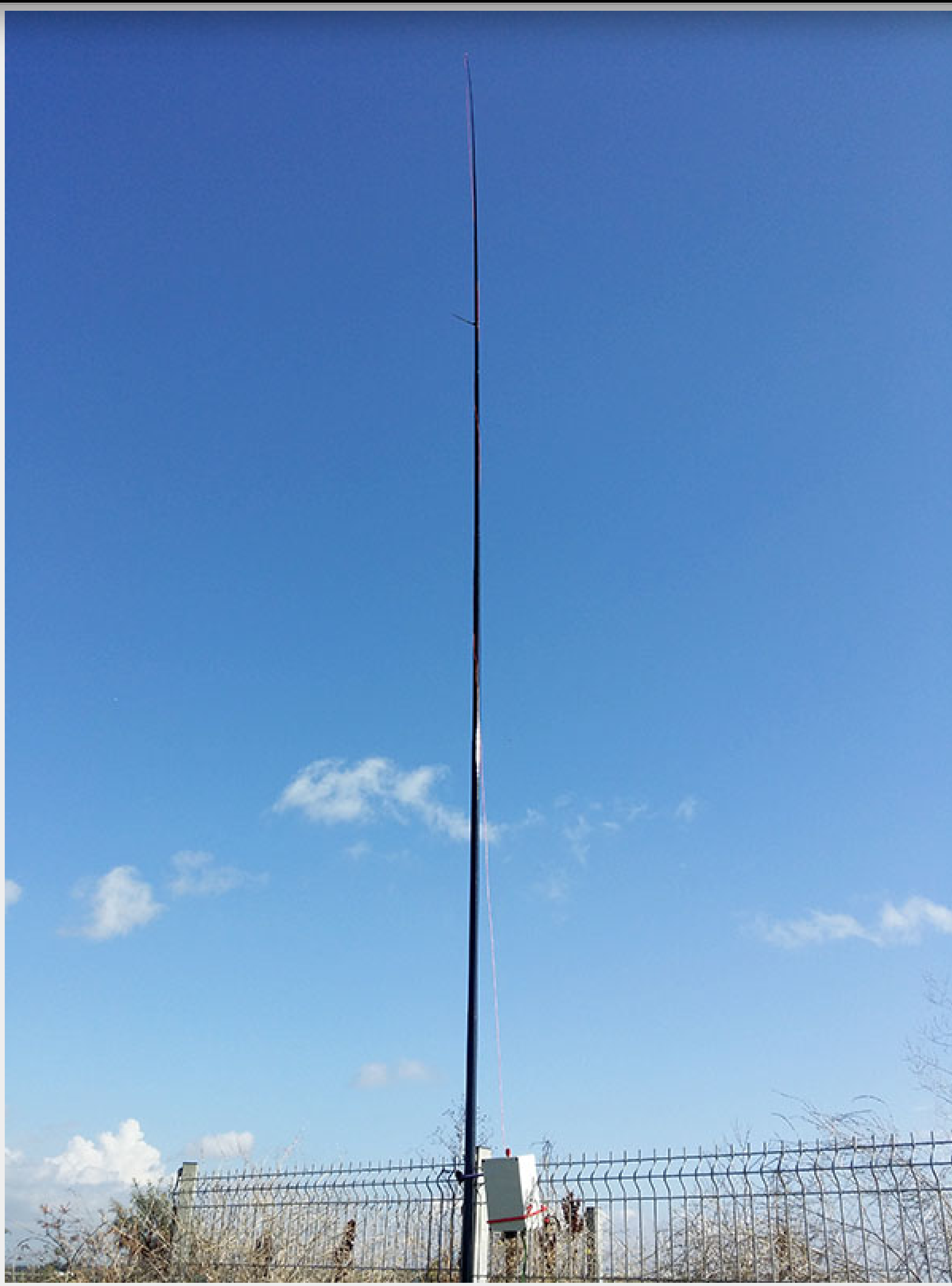
The completed End Fed Half Wave Coupler

The tuning control, SO239, ground switch and on the right, the counterpoise connection.

The antenna connection. The second hand box had a few holes in it, so I made this sticker to cover them up!

this is due to extra stray capacitance. I tuned the coupler to resonance into a resistor (in my case 3.2kΩ) so a 1:1 SWR was obtained on my chosen frequency of 21.25MHz, then I removed the resistor and attached the half wave antenna (6.65m) and counterpoise (66cm) from the above calculator. Without adjusting the variable capacitor, I had a 1:1 SWR. This confirmed that I had a resonant half wave and that I was feeding it at or very close to the peak voltage point and the feed impedance was around 3200Ω. I found that a small counterpoise was required. Sometimes, the stray capacitance to ground was good enough on its own, especially on the higher bands and if the coupler was laying on the ground. If its all away from ground, I get consistent results using the above setup. I have had good success also by using the coax as the return, by connecting the 'bottom' of the primary and secondary together via a switch to use the coax shield and transceiver as a counterpoise.

You may be able to adjust the capacitor to match the antenna if its not a perfect half wave, but then it will be a higher current feed and the simple ground system will be inadequate. The coupler will also not be working as it was designed and will be inefficient, generating heat. The coupler is a tuned impedance transformer, not an antenna 'tuning' unit. Stick to the above, and it should be a sure thing!



A half wave vertical for 21MHz. 6.65 metres of wire on a 9 metre fibreglass pole. The coupler is mounted 2 metres up and attached to the top of the fence. The 67cm counterpoise just hangs down in free air.

Below is a short video from my second test with the coupler, here on 17m.

END FED 6–40 Meter Multiband HF Antenna

Introduction

This EARC project produces an inexpensive, multiband, end fed HF antenna matchbox that is quick and easy to setup and use. The end fed feature adds portable convenience, but does present another issue. The problem with an end fed half wave antenna is that the antenna presents high impedance, creating a significant miss match with the usual transceiver impedance of 50 ohms. This miss match is significantly greater than typical tuners can accommodate without a matching transformer.

This project creates a trifilar wound, 9:1 UNUN (unbalance to unbalance) toroid matching transformer that will match the high input impedance of an end fed antenna into the range where most antenna tuners can produce good performance. The matchbox handles 100 watts of power. ***This project requires an antenna tuner to achieve satisfactory SWR***. If you need an auto tuner, we recommend the LDG line of auto tuners, shown to work well with these matchbox antennas, and highly rated by users. They are reasonably priced and available at most ham stores.

The matchbox project uses readily available common hardware and materials listed below.

Matchbox Parts List

1	small plastic enclosure (shown right)
1	powdered iron toroid T130-2
3	20” pieces of 18 AWG solid insulated copper wire in red, green, and black
2	# 8-32 x 3/4” hex head machine screws
2	# 8 lock washers
2	# 8 ring wire lugs
2	# 8 flat washers
2	# 8 lock washer/nut combination
2	# 8 wing nut
1	SO-239 panel mount connector to fit keyed enclosure opening

30’ # 18 AWG insulated stranded wire antenna with ring lug attached Small amount of clear silicone caulk to secure toroid in place

Preparing the MATCHBOX Plastic Enclosure

The enclosure needs one 5/8” hole for the SO-239 connector, and one 11/64” hole for the counterpoise wing nut on the lower side of the enclosure. An 11/64” hole on the upper right side of the box facilitates antenna connector mounting.

TOROID WINDING

First, wind the three 20” pieces of insulated solid wire onto the toroid. Place the wires as shown green-black-red, and wrap the toroid 9 turns so that it looks like the photo on the right. Notice there are three wires extending from the left winding and three wires extending from the right winding. As the connections are completed, the steps refer to the specific wires by left or right and color.

NOTE: Count turns by counting the number of times the wire goes thru the toroid center.

Crimp together and solder ***__the left black wire__*** with the ***__right red wire__*** When the step is completed, it will look like the right photo.

The next three steps should appear as shown in the first photo on page 3. Crimp and solder a # 8 lug to the ***__left red__*** wire about 2” from the toroid. The completed lug will later connect to the antenna connection bolt on the upper inside of the enclosure.

Twist the **__left green__** wire with the ***__right black__*** wire. Strip the ends of the two wires and twist together at about 2”. This twisted pair will solder to the center connection of the SO-239 connector in a later step.

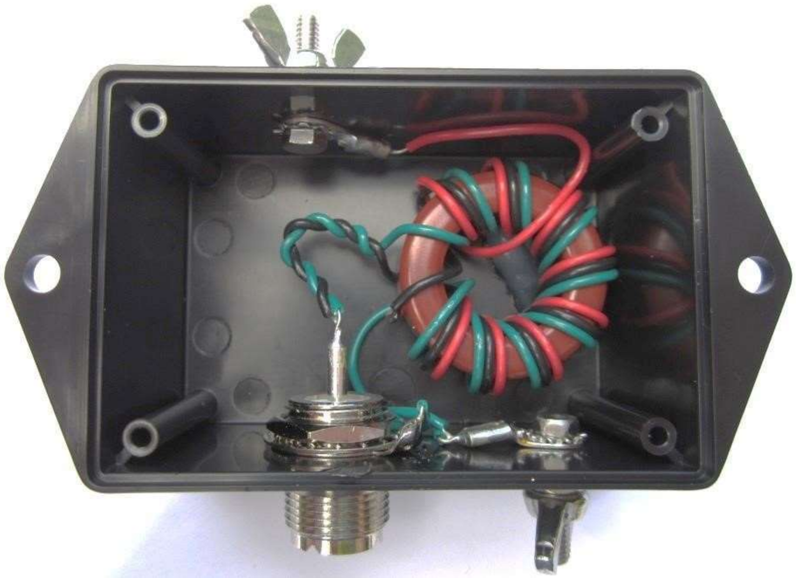
Trim and strip the remaining ***__right green__*** wire at about 2”. Cut an additional 2” piece of green wire, and crimp and solder both wires to a # 8 lug. The 2” green wire will connect to the ground

connector on the SO-239 already installed in the enclosure. Strip remaining green wire end 3/8" and bend into a hook for connection to the SO-239 ground connector.

The SO-239 connector and ground lug should be installed through the keyed hole in the lower right with the mounting nut securely tightened.

Solder the green and black twisted pair to the SO-239 center connector. Solder the green wire hook to the ground lug on the SO-239 connector.

From inside the box, place an 8-32 machine screw through a lock washer, the # 8 lug on the green wire, then through the lower 11/64'" mounting hole. Place a flat washer on the outside protruding machine screw followed by # 8 lock washer/nut and tighten securely. Place a # 8 wing nut on the machine screw to finish the **counterpoise connector**.



Position the toroid inside the box to allow connection of the red antenna wire lug to an 832 machine screw and lock- washer on the upper box side. Place a flat washer on the outside of the box followed with a # 8 lock washer/nut. Tighten the nut securely. Next, place the wing nut on the **antenna connector** and your project appears as shown above.

A small spot of clear silicone compound is used to secure the toroid from movement in the enclosure. The final assembly step is to secure the box cover in place with four screws.

Preparing the Antenna Wire

Matchbox performance will be determined by two factors: The length of the antenna wire, and the capability of the tuner. The length of the antenna wire should be between 24 and 60 feet for best performance. Additional counterpoise is not normally required, as the coax shield provides the counterpoise function. Wires longer than 60 feet may have excessive impedance for some tuners to properly match. Wires shorter than 24 feet may not radiate as effectively. A 30 foot insulated 18 gauge stranded wire antenna and connecting lug is included with the project and should meet most requirements without need for any counterpoise.

Experience has shown that most external tuners and some internal tuners will tune 80–6 meters with an antenna length of 24’ to 30’. If a longer antenna is desired, the provided antenna can be lengthened.

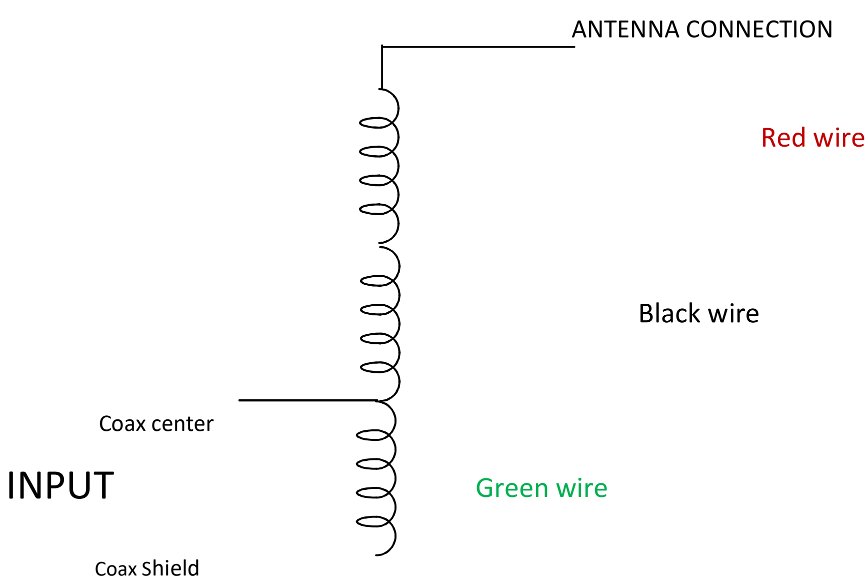
Some tuners, in particular internal tuners, may not tune the full 80-6 meter range. You may need to try different wire lengths to optimize your antenna configuration. If you are having difficulty getting your rig to tune, start with a 26’ wire. This should produce good results on at least 40-6 meters using the narrowest performance range of internal tuners.

Best performance is achieved with a coax of 16’ or longer, with the coax shield providing the counterpoise function. Additional counterpoise is usually not required in this design, although the lower wing nut provides a convenient counterpoise connector if needed. The end fed antenna system works well in horizontal, sloper, and vertical configurations.

Observe established safety practices when working with antennas, and avoid proximity to power or utility wires. Permanent installations should be equipped with appropriate static and lighting protection.

Keep amateur radio safe and fun!

Toroid Wiring Schematic



Feedback on 6-40 End Fed Matchbox Antennas

The antenna is amazing. I receive fantastic signal report from DX stations as well as hams around the country. I previously used a short version GR5V that was in an inverted V configuration on the roof of our house. This antenna was noisy but worked. Your antenna out performs the prior antenna and is much quieter. Thanks again for the fine product that your club offers. ***May 2012***

It took me 10 minutes to install and WOW - within 10 minutes I made my first HF contact (from CT to GA). And in the span of 4 hours made 3 more !! I was transmitting just 5 Watts from Yaesu 857ND using this antenna. This antenna rocks ! Thanks a ton ! 73 ***May 2012***

The 6 - 40 Matchbox antenna works great! Easily tunes with the Z100 tuner - very low SWR's on 20m thru 10m. Antenna was up about 45 feet on tree branch - wire length was about 52.5 feet, slight slope, 55 feet of coax, line isolator at radio. ***Work Hawaii for the very first time. Guess the antenna wanted to call home :-) 57 report, 100 watts, 15 Meter band, Icom 718.*** A great portable antenna that I will use often at Montrose Harbor along the lakefront in Chicago. Thank you for a fine, well made product. ***April 2012***

It arrived today in fine shape. I got is up in the air this afternoon using a 31 foot radiator. Top is at 45 feet. Loads on all bands 80-10M with my LDG auto-tuner absolutely no problem, My first QSO was KH7X in the ARRL SS contest with 100W. Amazing. This thing rocks! It's a great antenna! Nice job and a great buy. ***November 2011***

I set-up my jackite pole today and tried a 68' wire with the 9:1 unun matchbox. I set it up as an inverted L with about 26 feet vertical and 42 feet horizontal. With my IC-703 it tuned 80 through 6 all well below 1.5:1. I am going to leave the antenna up a few days and make a few contacts. I think the matchbox is terrific. ***October 2011***

My 6 – 40 meter end fed arrived through the UK holiday mail and I departed from my norm of a sloper and mounted it vertically on a 10m fishing pole. It is surprisingly effective and rewarded me with a surprise contact on 17m into the Falkland Islands at 20:30UT last night. ***January 2012***
When I attached it to a 10m fiberglass fishing pole and went vertical - wow! Easy 5/9 contacts out to 6,000+ miles when propagation was anything better than the worst. My simple ATU easily matches the antenna with SWR never greater than about 1.4 on any band it is built for. ***December 2012***

You can dither and procrastinate, but with this antenna, you'll be talking to the world in no time on any band that happens to be hot - and with your hard-earned cash hardly touched! ***January 2012***

Just wanted to report back that I have tossed the antenna into a tree about 20' up in an inverted vee shape and I am pleased to report that I can tune anywhere I need on 40-10M using the TS-590 internal tuner!! My first contact was on 40M within 10 minutes of erecting the antenna and was all the way to TX from my condo here in MI using just 10 watts. This is by far the best HAM related investment I have made in a long time. Living in a condo with strict association rules, I am able to conceal this wire in a tree out my bedroom window and talk all over. I'm very happy and would recommend this antenna to anyone in a similar situation. ***March 2013***

I have had your multiband end fed antenna installed here in Singapore for a few weeks now and am very pleased. I used the wire from my previous antenna which is 66 feet long. It works beautifully! I have it hanging vertically outside my 15th story apartment window on a 5 foot horizontal pole (to get it away from the reinforced concrete building). A couple of fish weights on the end keep it from blowing around too much. I would recommend this antenna to anyone who is facing a challenging QTH. ***April 2013*** I received my antenna yesterday, a quick 4 days since I ordered it. I attached it to a 31 foot pole and my IC-706MK2. Within minutes, I made my first contact with 9A4KW in Zagreb, Croatia on 20 meters. Being able to reach out over 4,000 miles gives me real confidence that I have found my portable antenna. Thanks for your rapid response and fine product. ***May 2013***

In only 2 weeks of casual on-air time. If you could see how I had to zig-zag it through a big tree above the roof of my RV, you'd be saying like I am, "how the heck can that work? I worked 90% of the stations I called, and just added Mexico City on 15m that gave me a 5x9. ***September 2013***

Just wanted to let you know how pleased I am with my ERAC matchbox antenna. I put the EARC antenna in the backyard with the feed point at 4 feet and the wire sloping up to 35 feet. I have 125 feet of coax feed line. My transceiver's built-in antenna tuner will adjust the SWR to below 1.2 to 1 on all bands 80-6 meters. Last weekend I worked 65 countries on 5 continents. I live in an antenna restricted community and this antenna has allowed me to enjoy ham radio again. ***February 2014***

I used the EARC Matchbox today. It works GREAT on 20m with a 30 ft radiator in vertical positioning, fed with 25ft of RG175/u coax. I've been talking up and down the east coast with 3W on SSB all afternoon! People ask me to repeat my power output again and again. I can't wait until I get the chance to use it at night, where I think it'll really shine! This has a permanent place in my portable kit. Thanks for the great product! ***April 2014***

I performed a simple install in Virginia making it vertical by using a 28 foot fiber glass kite pole. Within 30 minutes (NO KIDDING) I was receiving Lebanon on 17 meters! I also worked Russia and Eastern Europe that night on 20 meters. I love this antenna and I give it a 100% (5 STAR) rating. ***May 2014***

This little box is magic. NY, IA and NM from GA with ease on 100w ***June 2014***

Just wanted to let you guys know, this matchbox is wonderful. I built the matchbox, connected it to 55 feet of solid #14 about 20 feet in the air. My rig is a Yaesu FT-817ND connected to a MFJ-971 tuner with coax running between the tuner and the matchbox. So far I have worked Slovenia twice, Morocco, St. Helena Island, Cuba, Cost Rica, Vermont, Wyoming, Florida, North Dakota, Brazil, and Colombia. This setup works really well on the higher bands. Thank you for putting this design on the internet. I like it so much its become permanent here. ***September 2014***

This antenna continues to amaze me. It worked well U-shaped "indoors" with 50 watts, and now outdoors as a sloper. It easily loads 10-40m with my TS-570s internal tuner. I'm sold on it and own two of them now. I'm working at least 90% of the DX I chase. I have no RFI in the shack either. ***November 2014***

EARC Antennas are operating in virtually every state, these countries and more!

Argentina Australia Belgium Brazil Canada Chile Denmark Greece

Hong Kong India Ireland Israel Italy Mexico Mozambique New Zealand Russia Singapore Sweden Tasmania United Kingdom

ORDERING A MATCHBOX ANTENNA FROM EARC

Volunteers of the Honolulu Emergency Amateur Radio Club (EARC) carefully assemble the 6-40 End Fed matchbox antennas for those who prefer not to build one. For a donation of **$56** (Including USPS priority mail shipping) club volunteers will build and deliver a 6-40 matchbox with a 30 foot antenna wire anywhere in the U.S., we do not ship internationally. Note that coax cable is not included.

Payment by PayPal

To pay via **PayPal**, make your payment to paypal@earchi.org using any major credit card. Include your name, mailing address, and email address with the order.

We will ship promptly and you will likely receive the order in the US in 7 days or less. If you have any questions about your order, please email webmaster@earchi.org

Thank you for your interest in the activities of Honolulu Emergency Amateur Radio Club and amateur radio.

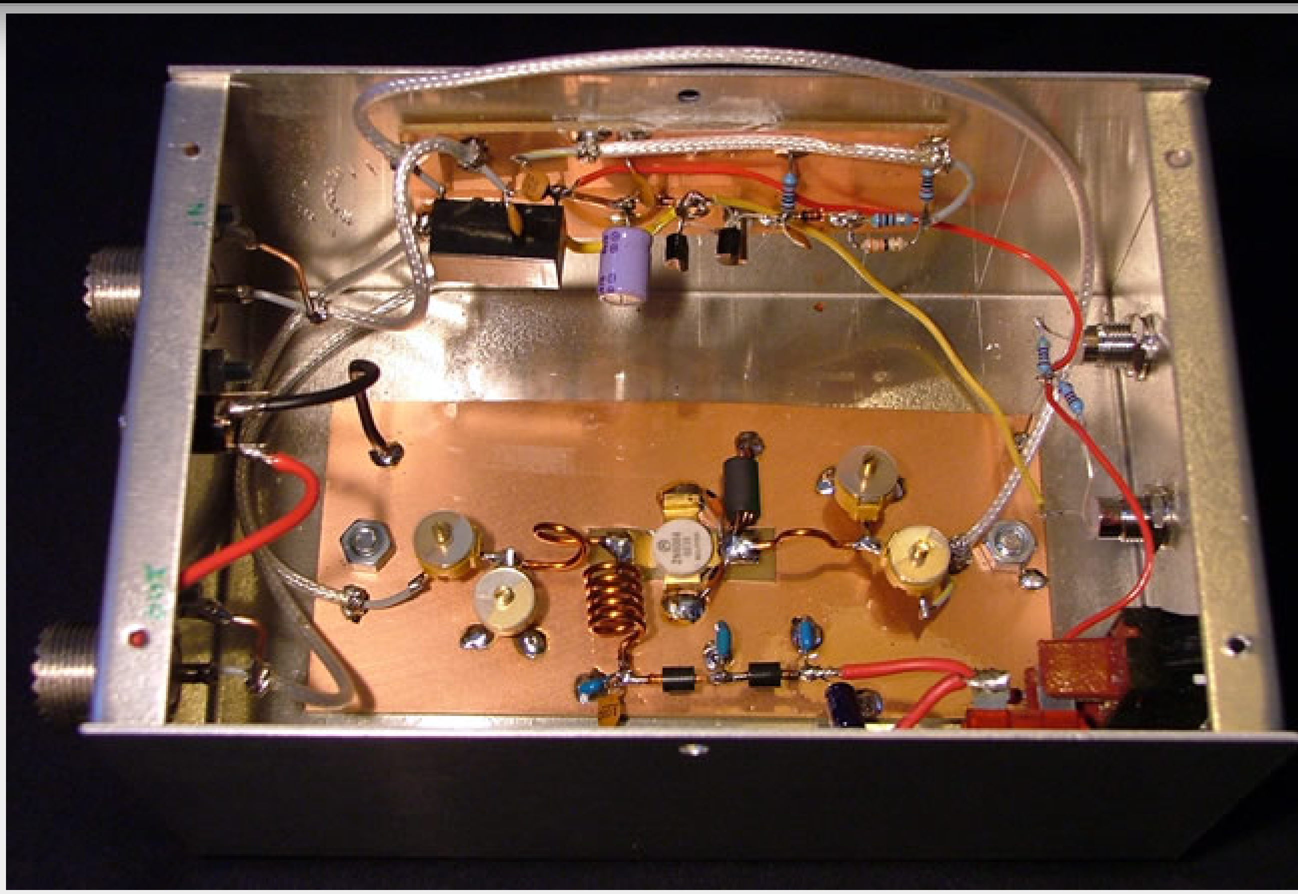
EARC
EMERGENCY
Amateur Radio Club

2N6084 144MHz FM Power Amplifier

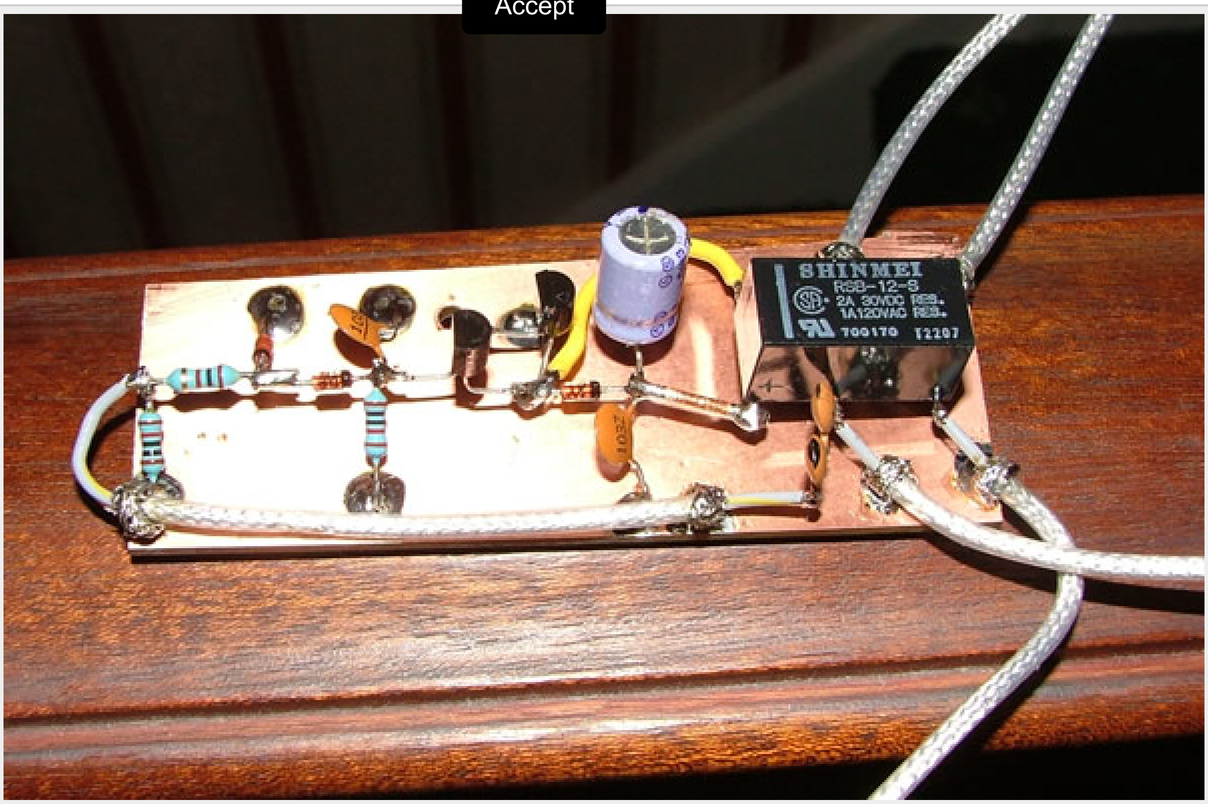
Simple 2m amplifier.

I built the PA board for this when I was a foundation licencee, but under the foundation licence, you must only use comercially made transmitters. Since getting my intermediate licence, I have put it in a box, and added an RF sensing switch so I can use it. It uses a 2N6084 RF transistor, and will produce 50w output max. It is a class C amplifier design, and therefore good for FM mode only. I have tried using the 2N6084 in class A, but amplifier gain was down to about 4dB and it seemed a but pointless!

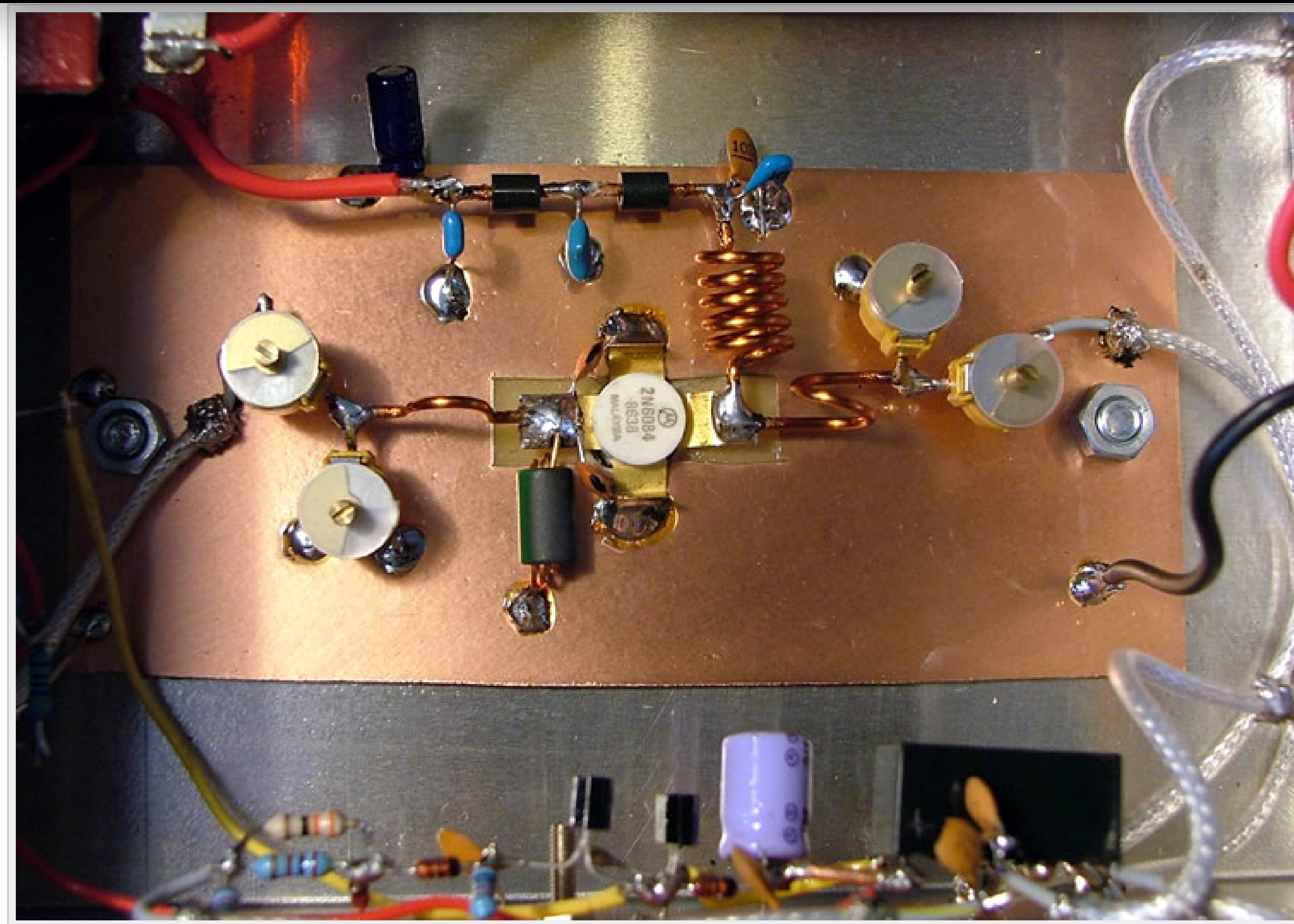
2.5w	10w
4w	20w
7w	30w
10w	40w
13w	50w



Inside the box

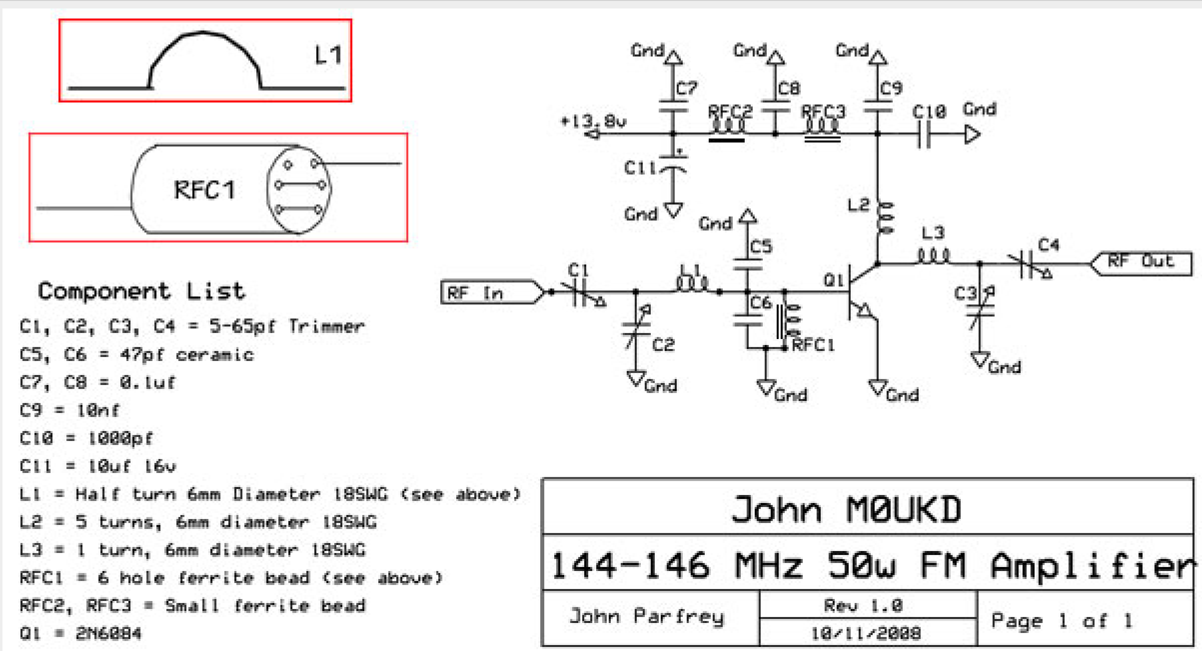


RF Sensing circuit & DPDT relay switch

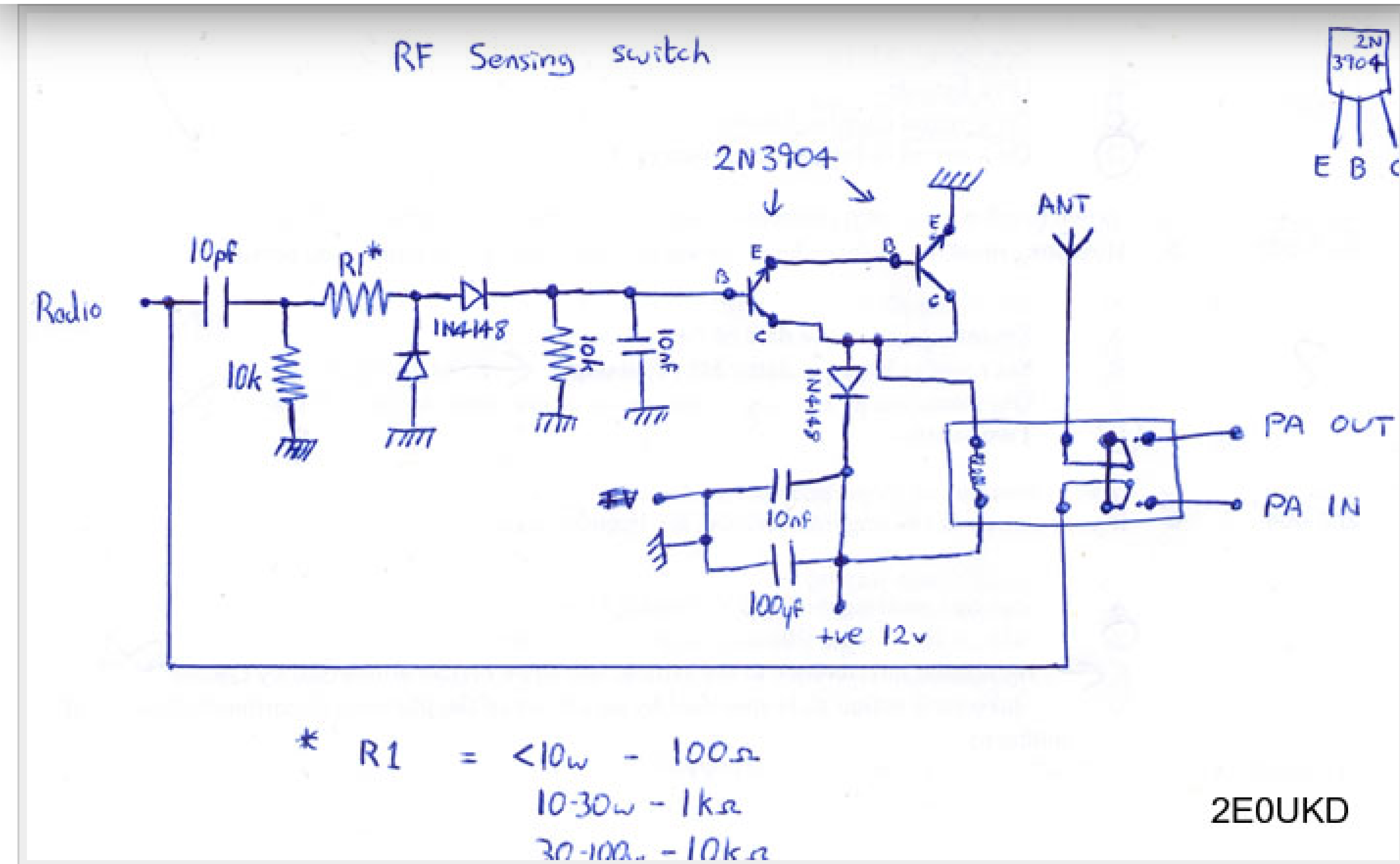


PA Stage

Back



Schematic of the PA board. CLICK IT FOR LARGE VERSION!



Schematic of RF sensing switch circuit.

MØUKD

MFJ-971 Portable Antenna Tuner Modifications

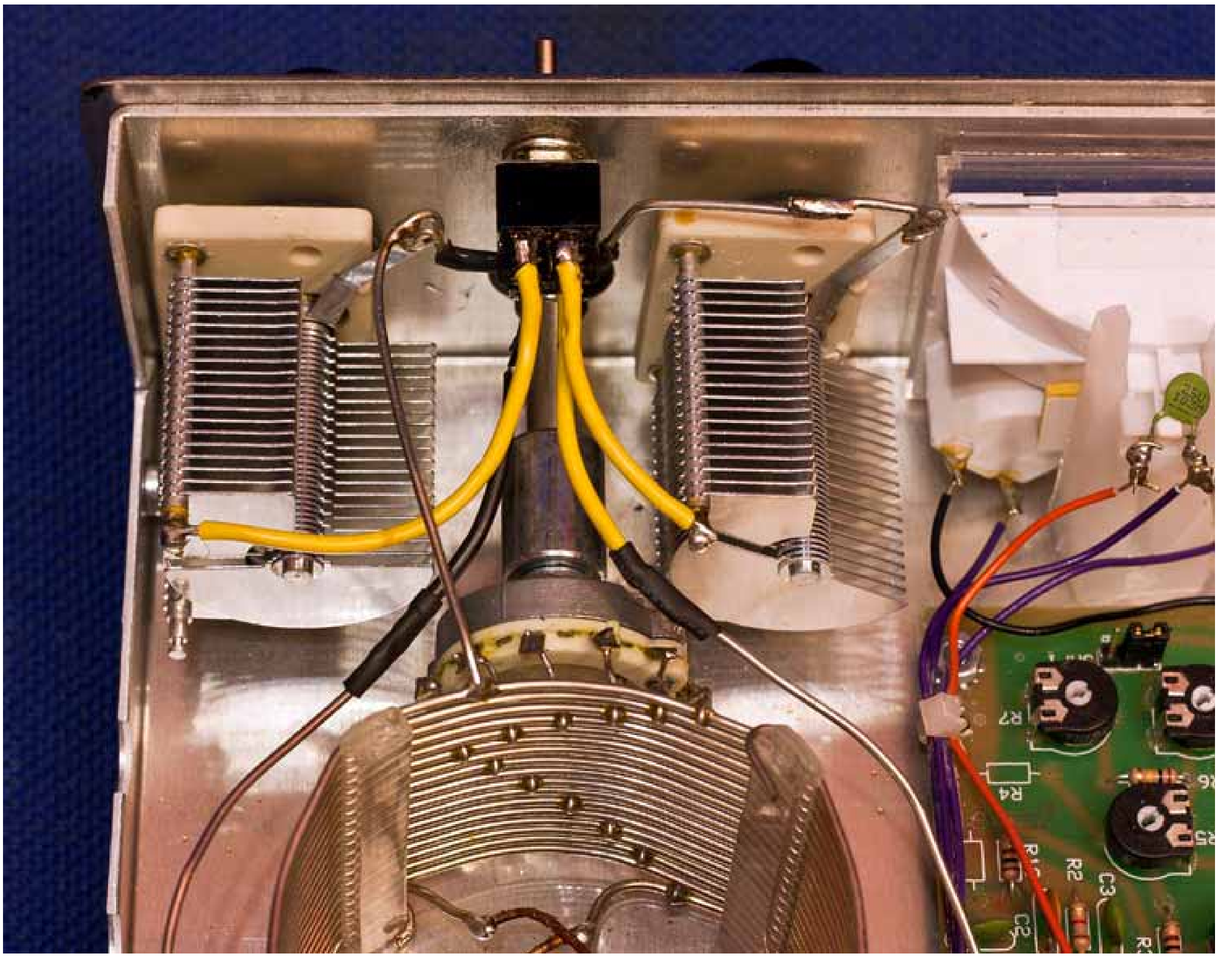
The MFJ-971 has the potential to be a great portable tuner. It is a small, compact tuner that has a sensitive SWR circuit allowing precise tuning with low power thanks to its 6w FSD setting and it has outputs for coax, wire and balanced feeder (although I won't talk about the MFJ 'heavy duty' 1:4 voltage baluns here!). To make it the almost perfect portable / QRP tuner, there were a couple of things that needed to be solved...

The problems I had with this tuner are:

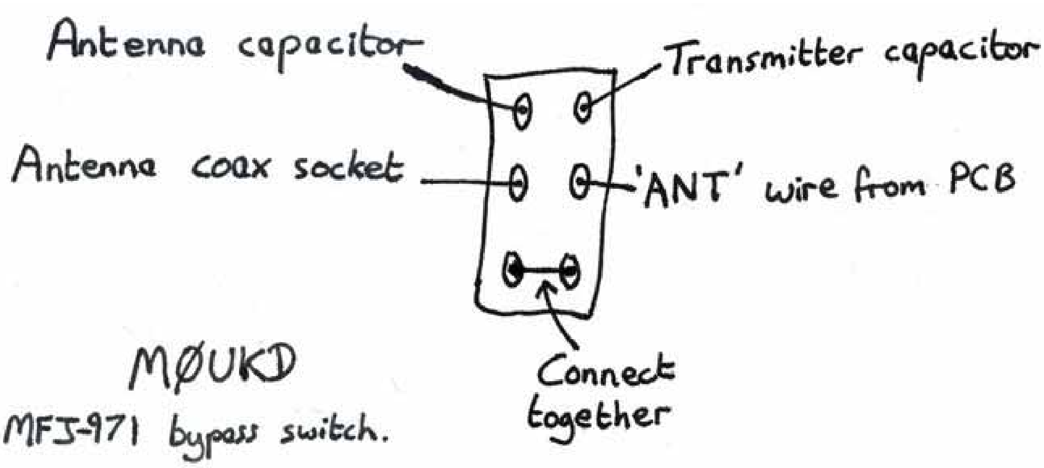
1) No bypass switch

2) Not enough inductance to tune on 1.8MHz

The first thing that I would want in any tuner, is a bypass switch. Its nice to flick a switch and be able to receive on all bands and the lack of a bypass switch is frustrating. This was easily added by mounting a DPDT switch to the front panel, and connecting it appropriately, as seen in the pictures below.



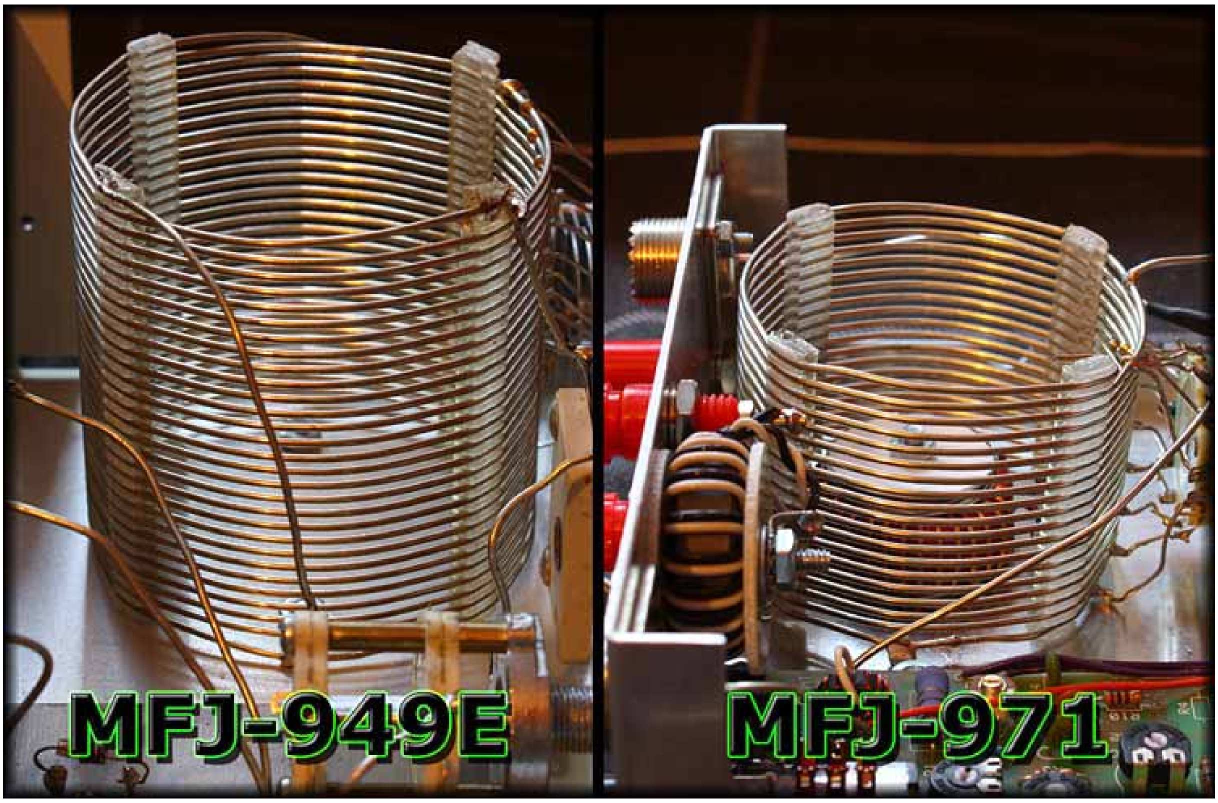
Usually, the signal comes off the PCB and straight into the 'transmitter' capacitor and the output of the 'antenna' capacitor goes to the coax/wire connection on the rear. The switch has been added to provide a way to bypass the tuner section. A drawing of the DPDT switch wiring is below.



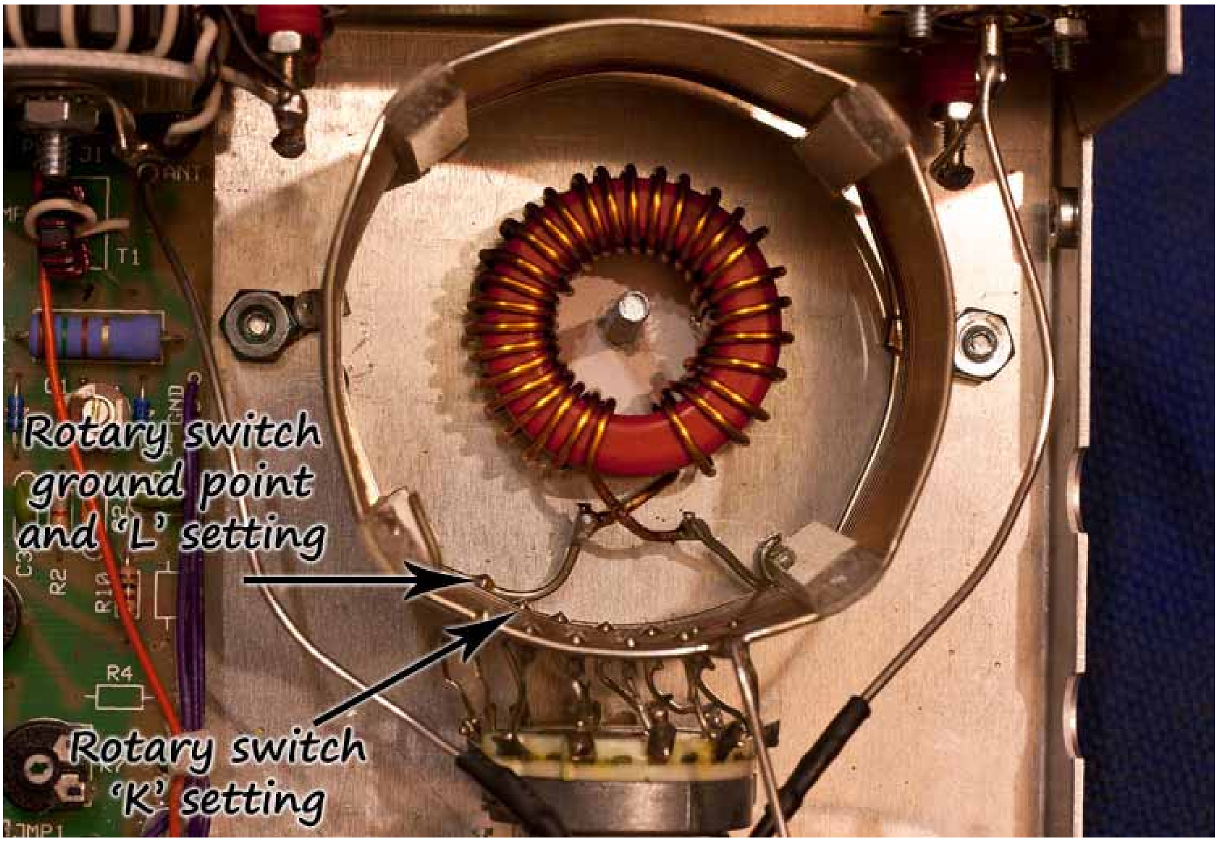
OK, now that annoyance is out of the way, lets fix the top band issue. MFJ say *'The [MFJ-971] T-match tuner covers*

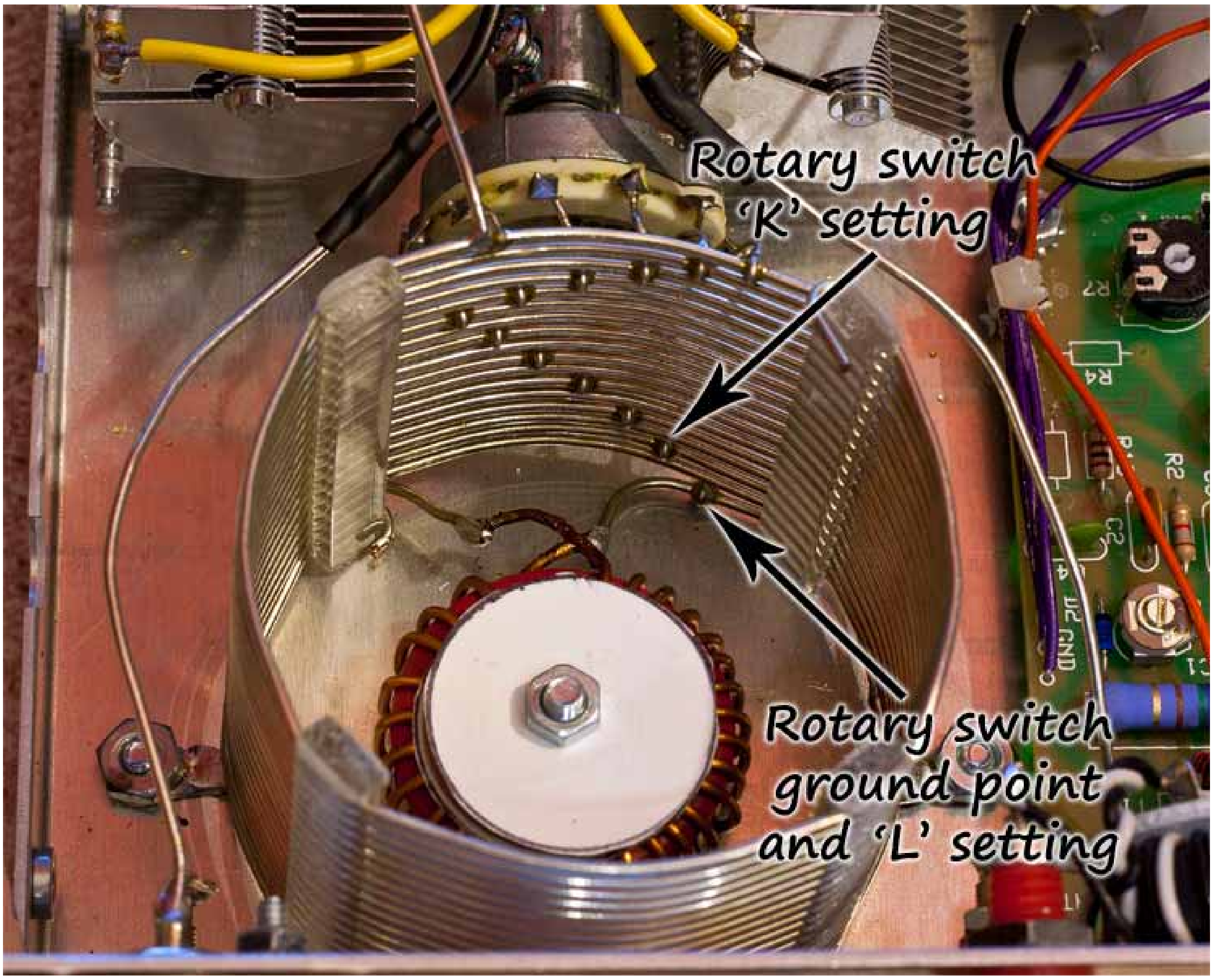
1.8-30 MHz'. It may well do, if you want to match a perfect 50Ω load on 1.8MHz! The inductor inside this tuner, although adequate for 80-10m, does not have enough inductance to be useful on 160m.

To overcome this problem, I included extra inductance by winding 29 turns of enamelled copper wire (any suitable insulated wire will do) on a T130-2 iron powder toroid, so when the tuner is on the 'L' inductance setting, the whole original inductor is used *plus* the extra inductance provided by the toroid. This does not affect any of the other settings from A-K.



The MFJ-949E inductor has 27 turns, 75mm long and 75mm diameter which is about 37µH.
The MFJ-971 inductor has 17 turns, 43mm long and 66mm diameter which is about 17µH.
Adding on the extra inductance means we have a max inductance of around 27µH which allows matching on 1.8MHz.
Air inductance coils can be calculated **here** and the T130-2 toroid **here**.

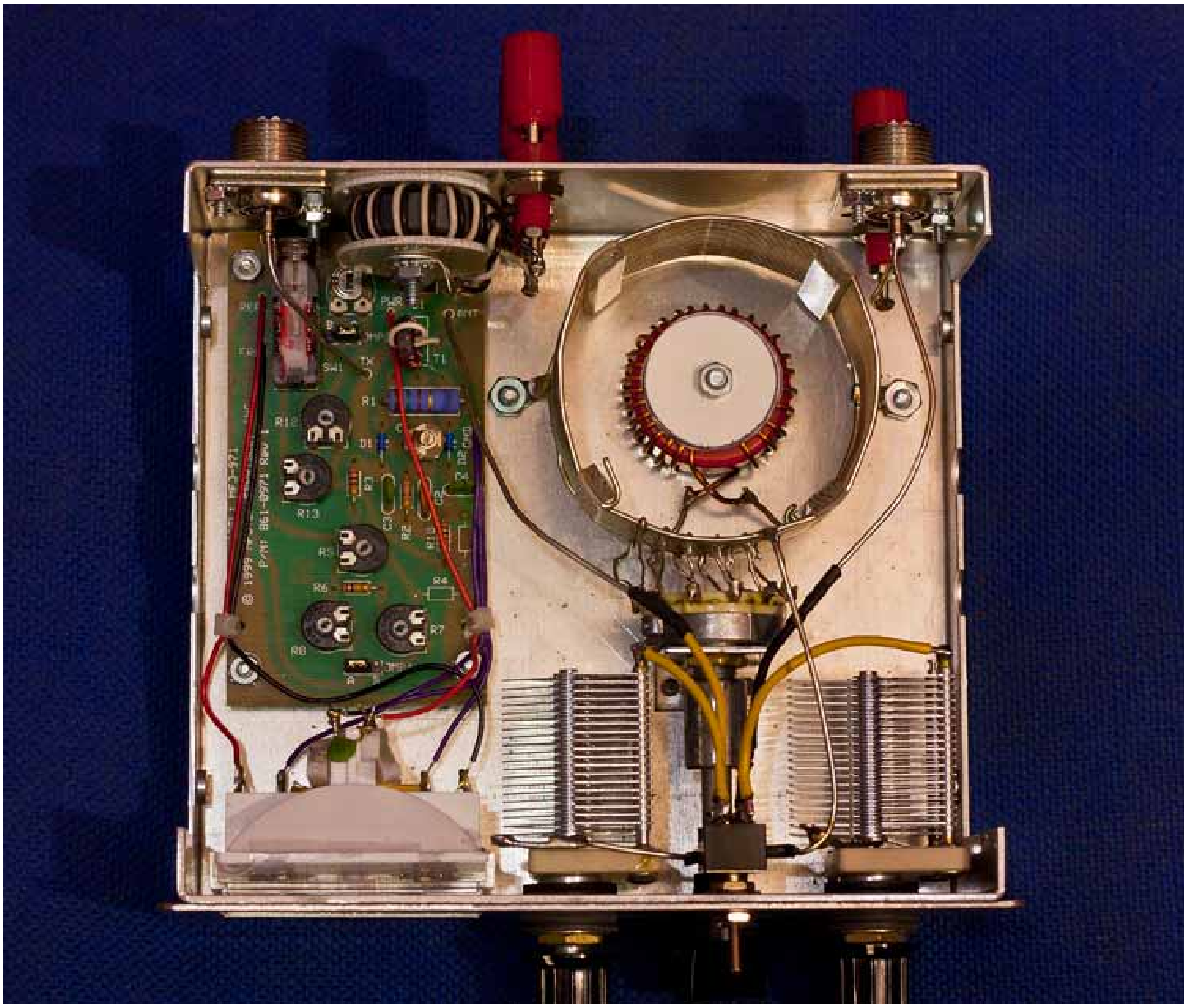




The inductor switch picks up its ground from the bottom of the inductor and this is also the 'L' setting, meaning the whole coil is in use when 'L' is selected. The 'K' inductance setting is 2 turns up from this point. I cut the wire just after the 'L' tap and inserted the extra inductance. Now, when 'L' is selected, the whole original inductor is in use, plus the extra inductance of the toroid, making it suitable for use on 160m! Of course, the 'K' setting still uses the whole original coil (less 2 turns) so nothing is really lost. The wires cross to keep any magnetic fields circulating the same way between the 2 inductors. The toroid is then fixed with a nut & bolt and suitable insulation washers either side of the toroid.

The completed, modified, much improved MFJ-971 is seen below. Please let me know if you perform any of these modifications, I'd be interested to know what you think.

There is one small problem remaining and that is RF BURNS! The nuts that hold the variable capacitors in place on many MFJ tuners are at RF potential. Most of the time they are hard to come into contact with being tucked away behind the control knobs, however, on the MFJ-971 the knobs must be pulled forward a little otherwise the metal inside the knob comes into contact with the metal shaft causing the grub screws that hold the two control knobs on to be at a high RF voltage. This can give you RF burns whilst you are tuning, even at 5 watts. I hate to imagine what the result would be if you put the 'rated' 200w into this thing and touched a control! One problem with pulling the knobs forward a little is that then the nuts themselves are more visible, although anything is better than an RF burn! 73 de M0UKD.



Amateur Radio MØMTJ

AERIALS (ANTENNAS) 1

Antennas 2 | Antennas 3 | Antennas 4 | Antennas 5 | Antennas 6 | Antennas 7

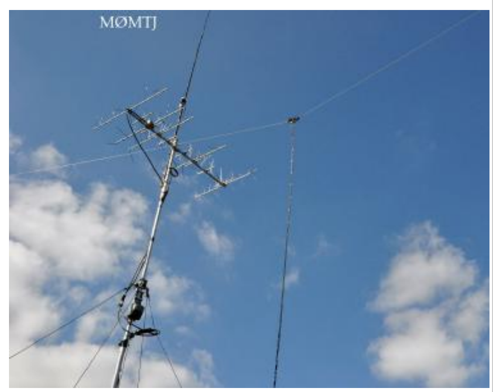
"Success is 90% antenna and 10% rig. Hobby is 90% listening 10% transmitting" *- MM0HDW.*

AERIALS used by MØMTJ

This page shows some the antennas that I have used over the course of time.

Index To Other Antenna Pages:

2014 : Current Set Up - as at September 2014:



The Summer of 2014 has seen a few changes of aerials. The 80m/40m Inverted L was removed and replaced with a newly constructed Doublet Antenna fed with ladder line via a 4:1 G-Whip current balun and an LDG "ATU". The Tecadi support pole originally used for the Inverted L is now used to support one end of the Doublet. You have probably read this elsewhere, but I can confirm that the All Band Doublet (fed with ladder line *not coax*) is a superb all round HF aerial. Highly recommended.

The SGC-230 Automatic Antenna Coupler was moved from the original feedpoint of the Inverted L antenna to the second feed-point on the other side of the garden. This now feeds a sloping wire of approximately 20 meters length to ensure that the 80 Meter Band and Top Band (160 meters) remain available. This antenna will also 'tune' on most other bands, so remains a very useful second antenna, though the All Band Doublet is often considerably better, particularly on the higher frequencies. The old SGC-230 was also faulty and I replaced it with a new CG-3000 auto coupler from Martin Lynch and Sons.

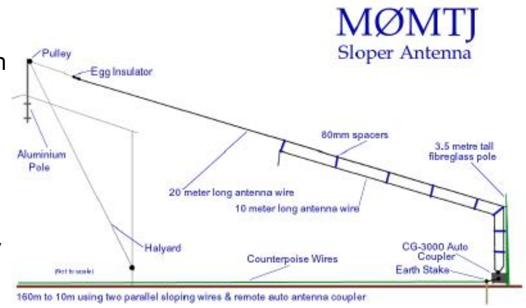
The J-Pole for 4 Meters (70 MHz) was removed since it wasn't used much, being only connected to a 4m hand-held radio - it seemed to be a waste of precious antenna space. This was replaced with a newly constructed Half Wave "CFR" Antenna (Coaxial Dipole) for 6 Meters (50 MHz) connected to the main HF radio via Westflex 103 coax. The DK7ZB dual band Yagi antenna remains, as does the 10m / 6m Fan Dipole in the loft space. Also remaining in place at the apex of the house is the home-brew 2m / 70cm "CFR" Antenna (Coaxial Dipole) for VHF/UHF FM operation - this has been a particularly effective antenna.

To sumarise:

1) A 20 meter long doublet antenna fed with balanced ladder line for 40 meters to 6 meters. The 'old timers' really knew their stuff, this an excellent all round antenna that is easy and cheap to make and should be quite easy to accommodate and install. See photograph below and read more here

2) A Sloper Antenna consisting of two parallel wires - one wire being 20 meters long with a second parallel wire

that is 10 meters in length. The first 2.5 meters (approx) of wire runs vertically up a non metallic post, then the remainder slopes back towards the house being finished off with an insulator which is attached to a Para-Cord lanyard that runs through a pulley on a pole at the apex of the roof. The antenna wire can therefore easily be let down for maintenance or adjustment whenever required. For lowest possible loss, the antenna is fed via a GC3000 automatic antenna coupler located at the bottom of the garden. The antenna is primarily for lower HF bands including 160 meters, 80 meters and and 40 meters, but it also works very well on some higher bands. The GC3000 itself is mounted in a waterproof IP56 rated enclosure near ground level at the bottom of the garden. Grounding is achieved from two 4 foot long copper ground stakes and several radial grounding wires.



Read more about the Sloper Antenna and the CG3000 here.

3) A 'home-brew' omnidirectional, vertical dual band, end fed antenna for 2 metres and 70cm. This is of the Controlled Feeder Radiation design (CFR) by VK2ZOI; effectively an end fed half wave dipole on 2m with an aluminium sleeve dipole section to achieve 70cms with a few extra dB's of gain. It is mounted on an aluminium mast. It's feed-point is about 11 metres a.g.l. read more here

4) A DK7ZB design dual band Yagi antenna, with 5 elements for 2 metres and 8 elements for 70cms, mounted horizontally for SSB. A lightweight antenna rotator is employed and uses a push-up telescopic mast. Height above ground level is again approximately 7 metres. The DK7ZB is an excellent twin band Yagi antenna. read more here

5) A Half Wave End Fed / Controlled Feeder Radiation (CFR) antenna for 6 meters / 50 MHz. Supported by a 3 meter long telescopic fibreglass fishing pole attached to the top of the aluminium push up mast that supports the DK7ZB dual band yagi and rotator.

6) Dual Band Fan Dipole, made from thick loudspeaker wire, mounted horizontally in the loft space for 10 meters an 6 metres. Cheap & quite effective.

Other Options that can be deployed on an 'as required basis' :

7) A half wave Wire J-Pole fixed to a telescopic fibreglass fishing pole for 10m. Cheap and effective. more about J-Poles here and also here on Antenna page 5

8) Compact Loaded Top Band Antenna, based on a design idea by Stuart Craigen G4GTX more

9 & 10) G Whip End Fed Zepps (EFZ's) for either 20m, 15m or 17m or the G-Whip "WideBander" which is an 'UnTenna' style antenna that can be used for 20m through to 10m using good quality G Whip 9:1 UnUn; useful additions for antenna flexibility. more

11) N9TAX Dual Band Slim Jim (J-Pole) antenna mounted in the loft as a back-up antenna for 2m and 70cms. Very good. more

12) Delta Loop Antenna - 16 metre loop of wire in triangular Delta shape, hung from the top of the pole supporting the inverted L antenna and fed via RG213 coaxial cable via a 4:1 balun. The loop is really a single band antenna cut for one wavelength on the band of interest, however it also can be pressed into service for some higher bands - a good, cheap and easy to install aerial; Often works better than the inverted L on the higher bands, but on 10 metres the tuned 10 metre dipole in the loft is sometimes better. more

Knots: Knots for securing wire aerials and other things more here

H.F. ANTENNAS used by M0MTJ

All Band Doublet Antenna

The Doublet Antenna consists of two 10 meter long top wires to form the 20 meter long 'dipole' section. The centre is fed with Ladder Line rather than coaxial cable. A dipole fed with coaxial cable is essentially a single band (mono band) antenna. Feeding such an aerial with ladder line, or open wire twin feeder makes a much more effective multi-band antenna.

The ladder line runs down to a high efficiency 4:1 Current Balun (G-Whip) which is connected to an LDG AT-200 automatic antenna matching unit via a very short RG213 patch lead to ensure lowest losses. The Antenna tuner and balun are housed in a box which is itself contained in a small garden shed to protect it from the weather. The LDG antenna matching unit is then connected back to the 'shack' via a run of RG-213 coaxial cable. Read more

about the All Band Doublet Antenna here.

A view of part of the MØMTJ All Band Doublet Antenna
Read more here

ANTENNAS FOR VHF and UHF - 2 m & 70 cms

The main antennas are as follows:

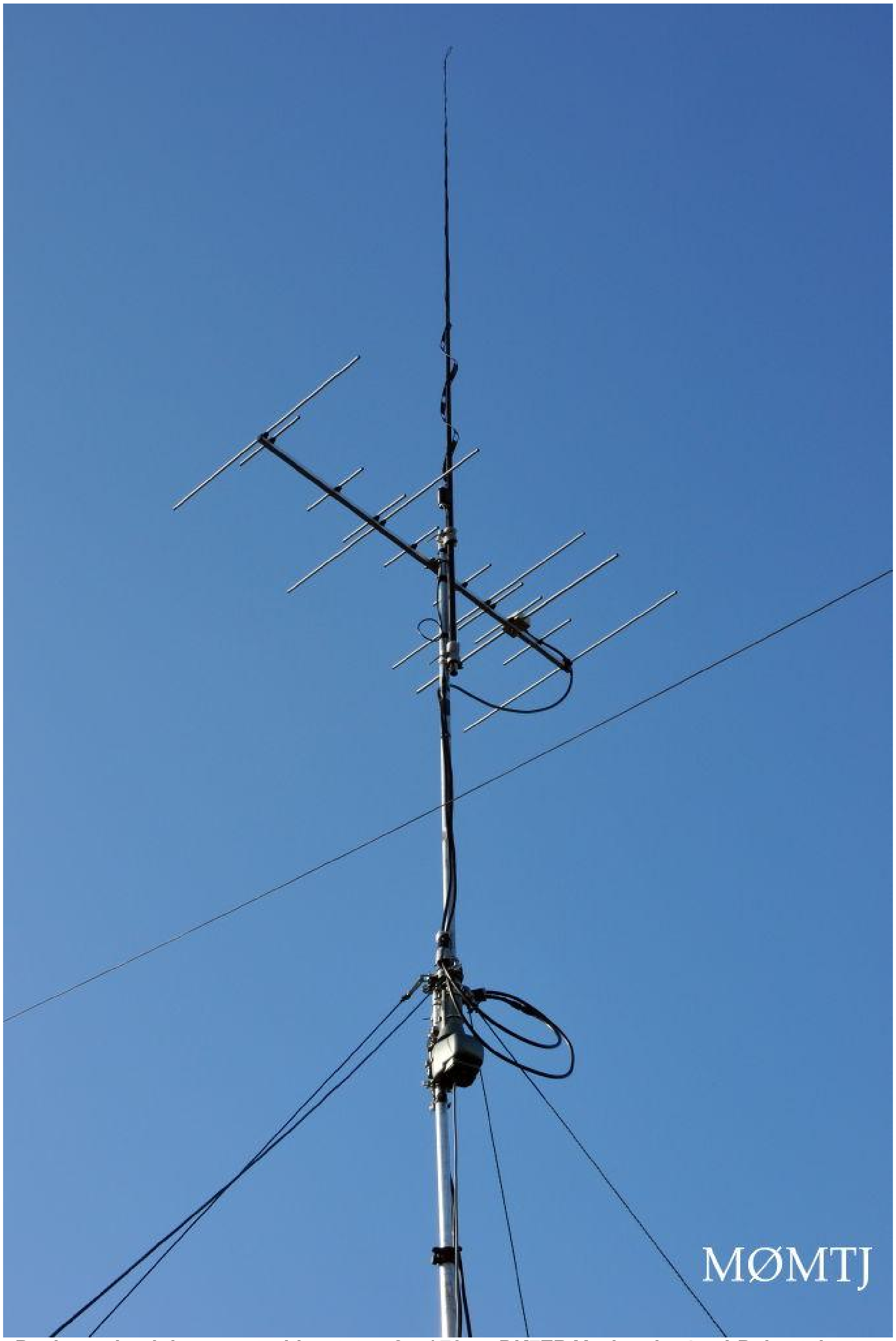
Home-Brew dual band end (physically end fed) half wave "Coaxial Dipole" for 2m & 70cm

For 2m and 70cm FM I use a mounted on a lightweight aluminium telescopic pole on the apex of the hose. The base of the antenna (the bottom of the radiating element) is approximately 11 metres above ground level. This antenna is based on the Controlled Feeder Radiation principle (CFR) and is described by VK2ZOI. Read more about its construction here. Also seen in the photograph below are the ropes that support the H.F. wire aerials.

Home brew dual band vertical antenna for 2 metres and 70 cms
Read more about its construction here

Dual Band Yagi for 2m & 70cm

For 2 metres and 70cms SSB there is a horizontal DK7ZB design dual band Yagi antenna. This has 5 elements for 2 metres and 8 elements for 70 cms. A lightweight antenna rotator is employed and uses the same push-up telescopic mast that the Home-Brew 70MHz J-Pole is mounted on. Height above ground level is again approximately 7 metres. The DK7ZB is an excellent twin band Yagi antenna**.**



Push up aluminium mast with rotator, 2m / 70cm DK7ZB Yagi and a 4m J-Pole at the top

The DK7ZB 5 + 8 element dual band yagi for 2m and 70 cm - designed by Martin Steyer DK7ZB
Available from Arthur M0PLK (SQ2PLK) at Ham Radio Shop:
http://stores.ebay.co.uk/urbasket-eu
http://ham-radio.urbasket.eu
Also available from VPA SYSTEMS by SQ9VPA http://www.vpa-systems.pl
Kits available from NUXCOM.de : http://shop.nuxcom.de

2 Meter J-Pole Antenna for the garden shed - and other J-Pole antennas for 6 metres and 10 metres :

While experimenting with antennas in the garden in the summer of 2012 I thought that it would be good to have a hand-held radio in the shed to do some monitoring and make a few contacts. To improve upon the performance of the 'rubber duck' antenna I quickly made a J-Pole antenna for the 2 metre band.

It is made from a 47cm length of 450 ohm Wireman ladder line as the 1/4 wave matching section, plus a 97cm length of stranded wire as the 1/2 wave radiator. It is fed with 3 metres of Mil spec RG58 c/u coaxial cable that is soldered to the 1/4 wave matching section's impedance matching point at 3.5 cm from the bottom. The coax feeder is wound around some PVC tube to form a choke. The completed antenna is taped to a 2.2 metre long fibreglass fishing pole that I purchased from Poundland (for £1.00). It took about 20 minutes to make followed by some testing and adjustment with the antenna analyser. The fishing pole is lashed to the shed with some cable ties.

This simple antenna works pretty well, but being so low down signal strengths are not huge, but it's pleasing to get on the air with something so simple and cheap!

Find out how easy it is to construct J-Pole Antennas here

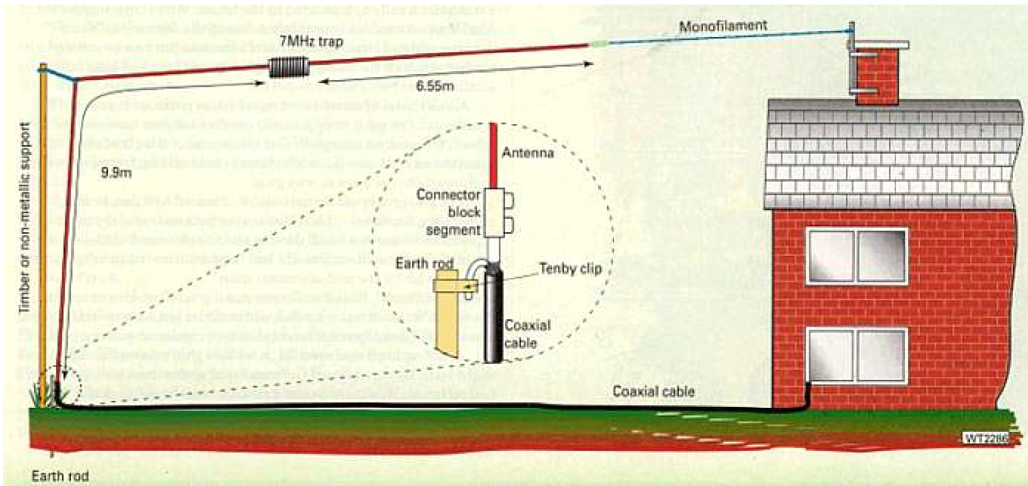
Now, if it was at the top of my 10 metre long fishing pole. . . . . (!)

The Shed Antenna - a 2m J-Pole by M0MTJ
Note the simple choke balun at its base made by winding 8 turns
of the coaxial cable around a small off cut of white PVC water pipe.
Find out how easy it is to construct J-Pole Antennas here

The feed point of a J-Pole antenna made from Wireman 450 ohm ladder line.
[More here]

More Antennas . . .

Inverted L Antenna for 80m and 40m (and some other HF Bands from 80m to 10m)



The basic layout of the Inverted L Antenna (Practical Wireless)

The first antenna that I installed was for HF. I decided on an Inverted L that incorporates a 7MHz trap so that it can be used on both 7MHz (40 metres) and 3.5 MHz (80 metres).

The design of this Inverted L is well known and a good design has been published previously in Practical Wireless by Len Paget GM0ONX. It is based on one half of the famous W3DZZ trapped dipole antenna.

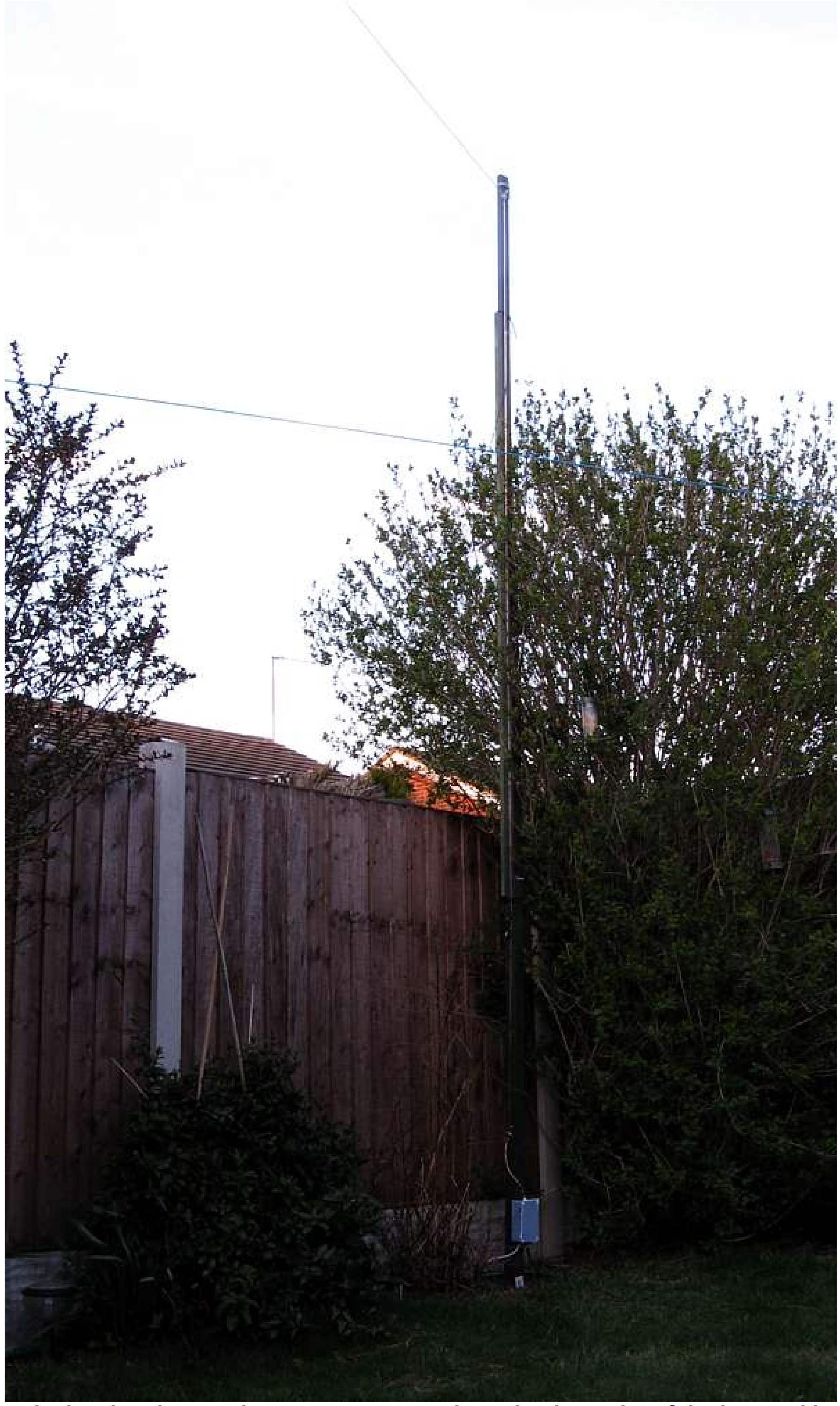
It can be made entirely from scratch as a DIY project, or the 7MHz trap could be purchased commercially as a ready made item, or whole antenna can bought as a complete kit from Tony Nailer, G4CFY, at Spectrum Communications. I opted to buy the 7MHz trap from Spectrum Communications, as I already had most of the other materials required - rope, egg insulator, plastic box, and some good aerial wire. The Spectrum Communications trap is solid and well made and 'potted' to protect against the elements.

This antenna is tuned for 40 metres and 80 metres, but the VSWR is acceptable on several other bands being in the region of 2:1 to 5:1. The designer anticipated that this antenna would be usable on five of the H.F. bands between 80m and 10m.

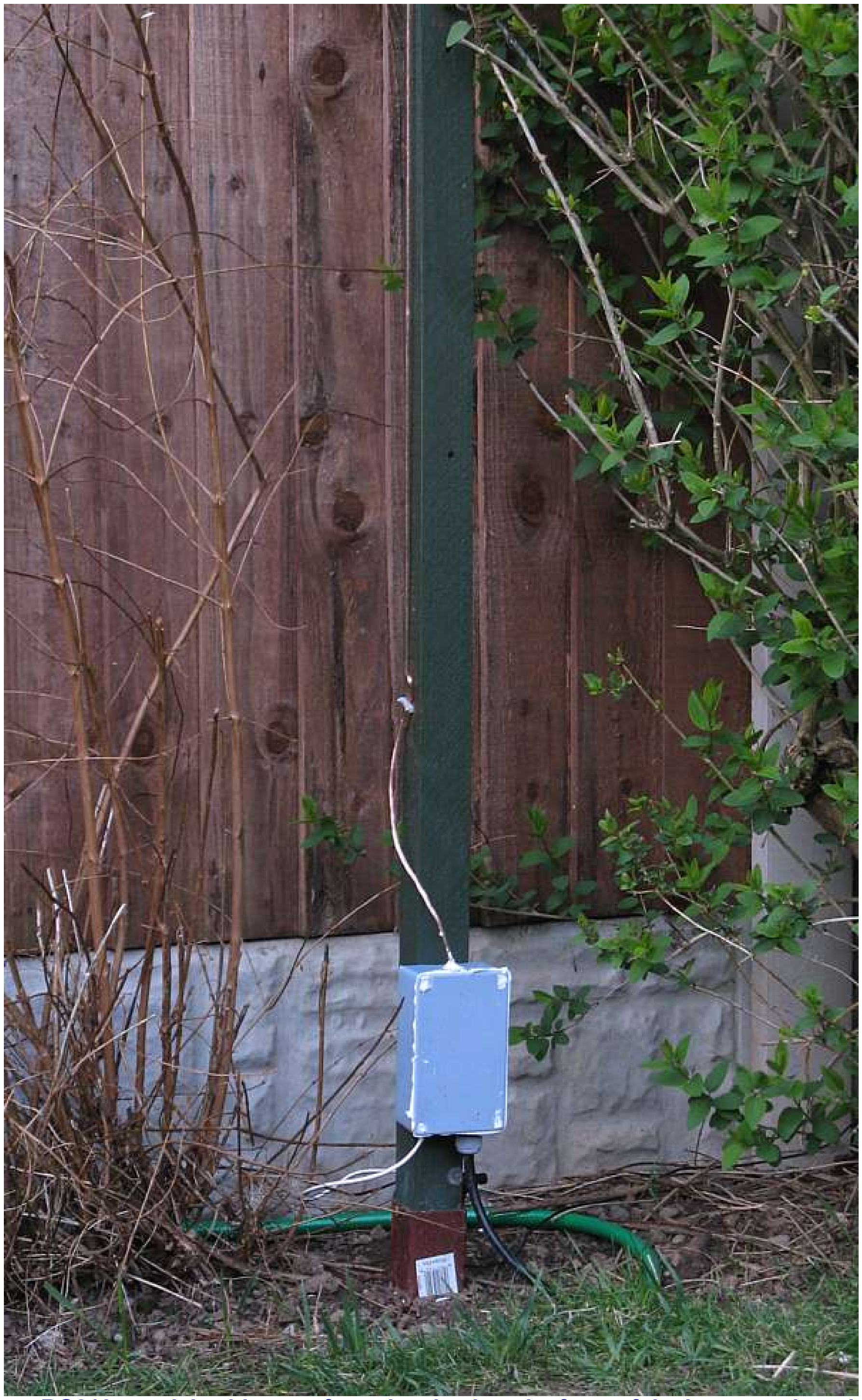
I have found that with the use of the Antenna Tuning Unit it can be used on all of the H.F. bands. However the polar radiation pattern may very well be less predictable on bands other than the intended 40 and 80 metres, and it may well be less effective than might be desirable - but it does work!

The antenna is in the back garden, while the shack (radio room) is in a bedroom at the front of the house. It is fed by a 30 metre length of RG213 coaxial cable (it is not possible to use twin feeder for this type of antenna as the Inverted L is an UN-Balanced aerial, whereas twin feeder is balanced). With this length of cable I estimate the loss in the feeder alone to be about 1dB at 7MHz. The feed point of the aerial is located at the base of a 16 foot high wooden pole near the bottom of the garden. The horizontal top wire returns to a fibreglass pole installed at the apex of the roof.

+ 17 + 160: I have since added a separate sloping wire element for the 17 Metre Band and a switchable loading coil for Top Band - see notes below...



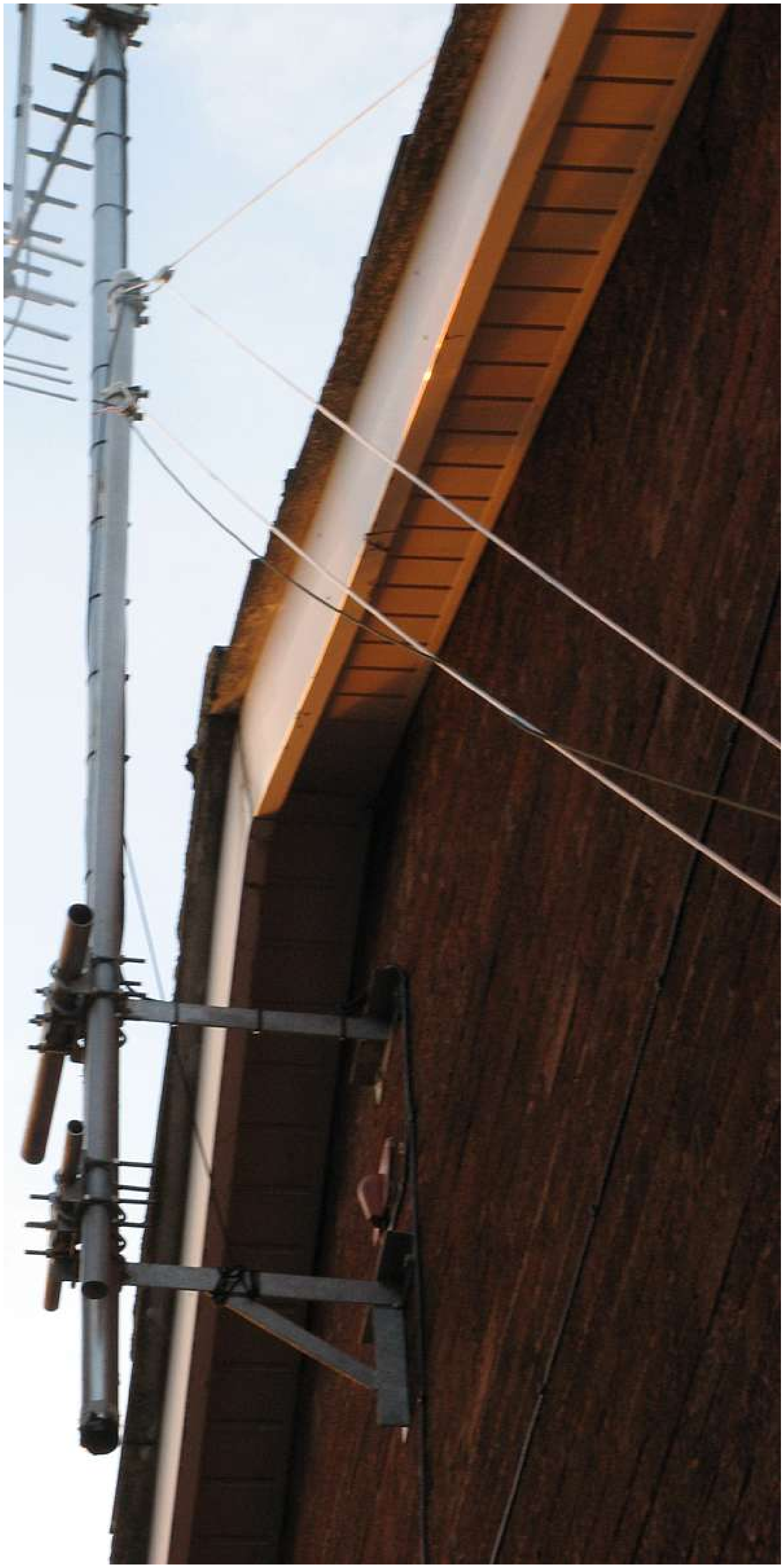
Photograph showing the wooden support post and termination point of the Inverted L antenna The post is coloured green with green fence treatment to mast it somewhat. I have also placed it near the bush to provide further camouflage.



The low loss RG213 coaxial cable runs from the shack at the front of the house up into the loft and exits into the back garden down the rear wall, through some garden hose to offer some protection along the flower bed to the bottom of the garden where it is connected to the base of the Inverted L antenna.

The suspended Inverted L aerial with 7 MHz trap.

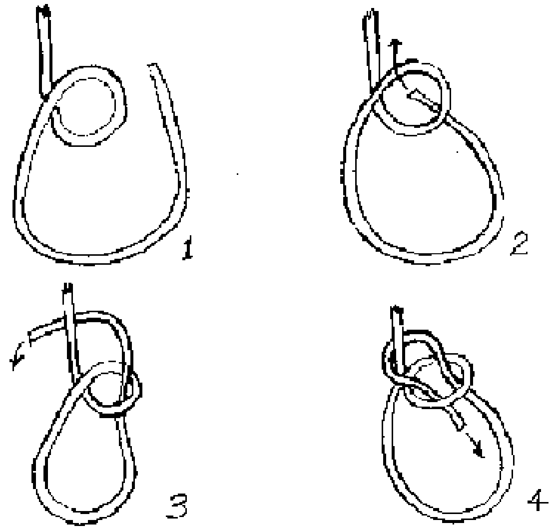
The Inverted L antenna - lower section now nicely camouflaged. The wooden support post is some 6 metres long.



The photograph above shows the Dacron ropes supporting the ends of the Inverted L and Dipole antennas are held in place at the top of the fibreglass support mast by a pulley - one pulley for each support rope. This facilitates rapid lowering of either antenna for adjustment or replacement. This photograph also shows a second rope and pulley system that was originally used to support the 20m dipole and is now used for the top band inverted L wire

aerial.

I needed a good reliable knot for securing ropes when installing wire antennas and have found the Bowline to be one of the most useful, it is strong and easy to tie. A Bowline will not slip in any circumstances and, usefully, the more load that is put on it, the tighter it gets.



The Bowline Knot

A Bowline can be used to tie two ropes together and should be used to tie a support rope to a pulley, dipole centre and other antenna items.

It's important to use the correct knot for the job when fixing up wire antennas. I find the Bowline is a very useful for fixing end, egg and dog-bone insulators to the ends of the wire and/or ropes. The Round Turn & Two Hitches, Anchor Bend (Anchor Hitch) and Buntline Hitch knots are very good for tying a rope to a pole or a mast. A Double Sheet Bend can join two pieces of rope together - even if they are of unequal size. 'Animated Knots' will show you how to do them: http://www.animatedknots.com

Photo showing pulley fixed to the top of the wooden support post and the aerial support rope that it holds in place.

The Spectrum Communications Trap

View of trap showing that the joints have been thoroughly sealed against the weather with self amalgamating tape and silicone sealant.

Just for good measure I sealed the internal side of the machine screw that forms the connection terminal against the weather with Watson sealant putty.

Adding Top Band to the 80 / 40 metre Inverted L Antenna:

Due to an aborted house move in 2010 I had removed all the antennas. While re-establishing the aerials in 2011, and considering space limitations, I decided to experiment with adding a loading coil to the 40m / 80m Inverted L aerial. The loading coil has a link wire to short it out of circuit when using the aerial for 80 metres and 40 metres. The link wire is removed when Top Band is required.

I also took the opportunity to replace the original wooden post with a strong 6 metre tall fibreglass pole.

The coil consists of approximately 37 turns of PVC covered antenna wire wound on a short piece of PVC pipe. Once the required points of resonance were set for 40 metres and 80 metres, the link wire was removed and number of turns on the coil were adjusted until the required point of resonance was found on the 160 metre band. I set it to around 1900 kHz - the bandwidth is quite narrow.

Once the work was done, the joints and connections were sealed with either Liquid Electrical Tape or self amalgamating tape, then the connecting box, V bolts and white PVC pipe were sprayed with green paint to help it all blend in with the surroundings a little better.

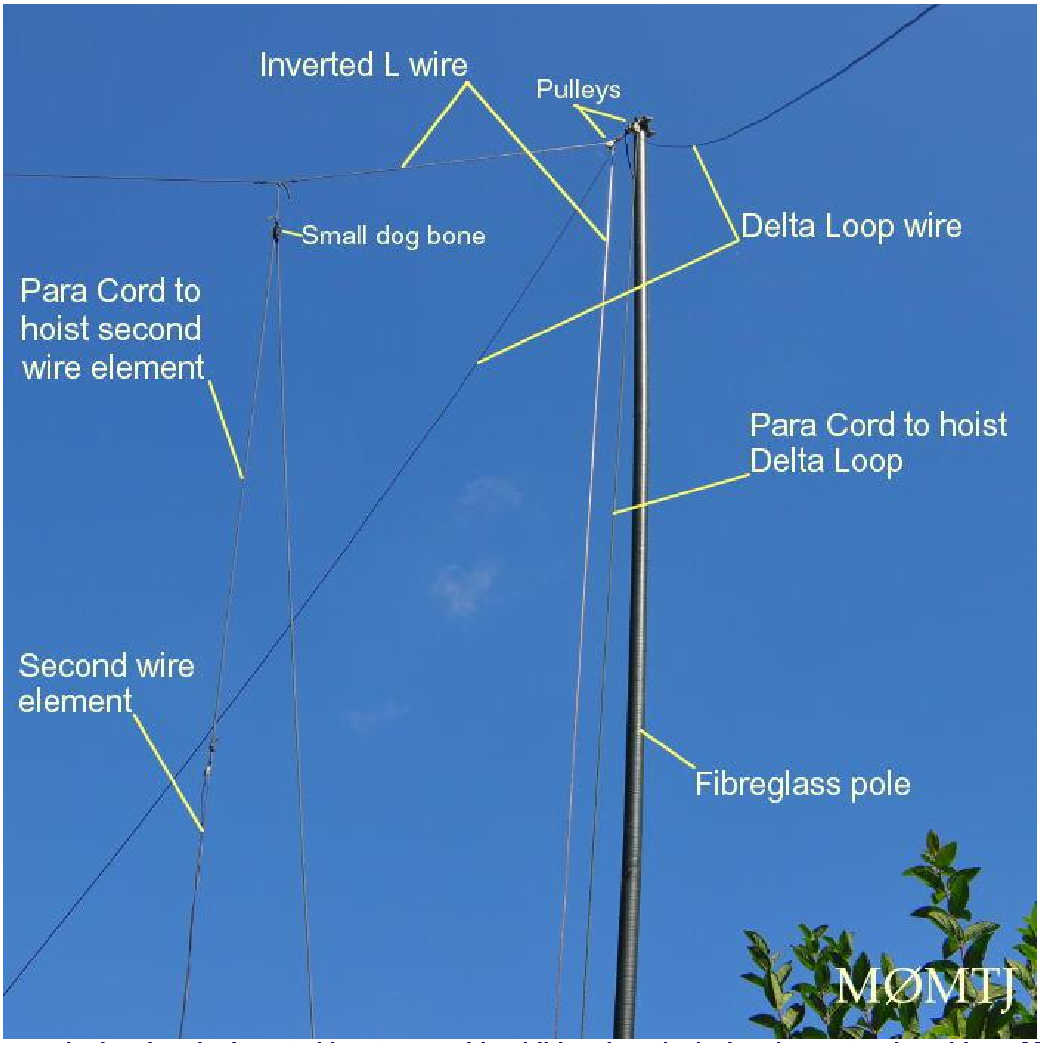
Adding the 17 Metre (18 MHz) Band to the 80 / 40 metre Inverted L Antenna:

The Inverted L is not too good for the 'WARC' bands so to obtain better performance on the 17 Metre band I added a single slightly sloping wire element cut for that band. The lower end of the wire is permanently connected to the feed terminal on the junction box, the other end is tied to a small dog bone insulator. This dog bone is then supported by a length of thin para-cord which is tied to the horizontal wire of the main Inverted L element. (N.B. The 17 metre modification is not currently shown in the photographs below.)

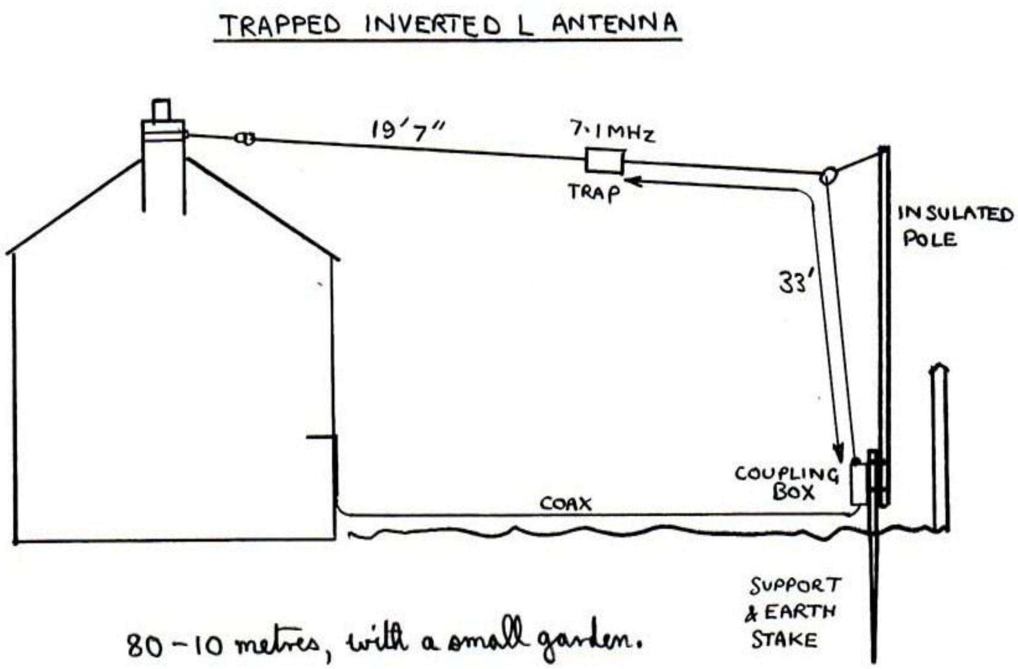
Work In Progress! - September 2011
Reconfiguring Inverted L with additional Top Band Loading Coil for 160 metres.
A strong 6 metre tall fibreglass pole replaces the original heavy wooden post.

Adding 160 metre loading coil to the 80m / 40m Inverted L Aerial.
The loading coil has a link wire to short it out of circuit when using the aerial for 80 metres and 40 metres.
The link wire is removed when Top Band is required.
The coil consists of approximately 37 turns wound on a piece of PVC pipe.

Adding 160 metre loading coil to the 80m / 40m Inverted L Aerial.
The loading coil has a link wire to short it out of circuit when using the aerial for 80 metres and 40 metres.
The link wire is removed when Top Band is required.
The coil consists of approximately 37 turns wound on a piece of PVC pipe.



Photograph showing the Inverted L antenna with additional vertical wire element and position of Delta Loop



The commercial version of the basic 80m - 10m Inverted L is available from Tony Nailer at [Spectrum Communications]

Important notes on effective Grounding by Jim K8OZ

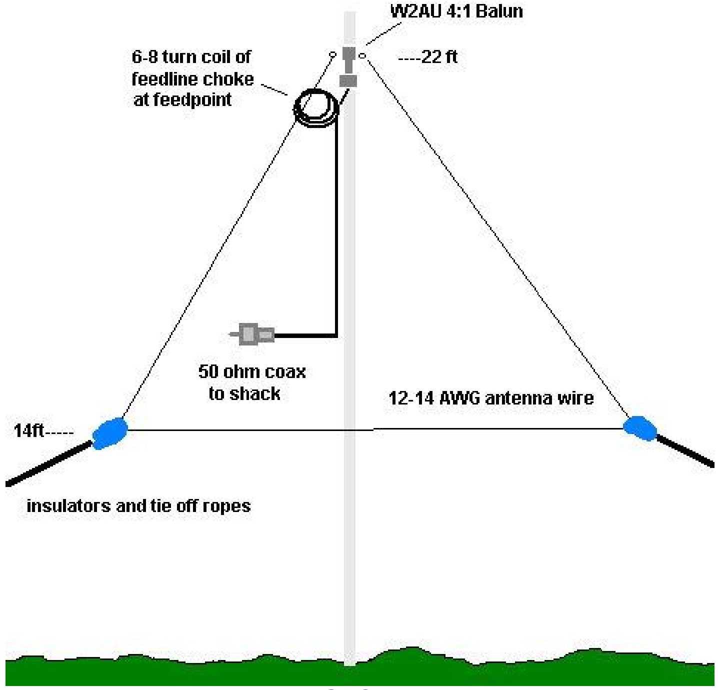
Mike - I was reading about your work on the 160 meter Inverted L, and it makes me want to go out and build some more antennas! Congratulations. Your story is fascinating, and very well documented.

The only thing I can offer as a suggestion is to get as much radial wire along the edge of your property as possible (assuming your XYL will not allow you to bury radial wire all over your yard). Even if you can only run multiple wires 1/8th of a meter apart from each other, and parallel to each other, your losses will be reduced. The ground lossses have quite an impact on your transmitted signal, so any wire you can "hide" along the edge of your property will help improve your signal strentgh - little, by little...! { It may also affect your resonant frequency slightly, but that's easy to deal with by adjusting with an antenna tuner or slightly changing the loading coil. }

Good luck OM, and keep up the refinements on your antenna system. You're doing great! 73,

Jim, K8OZ
Albuquerque, NM

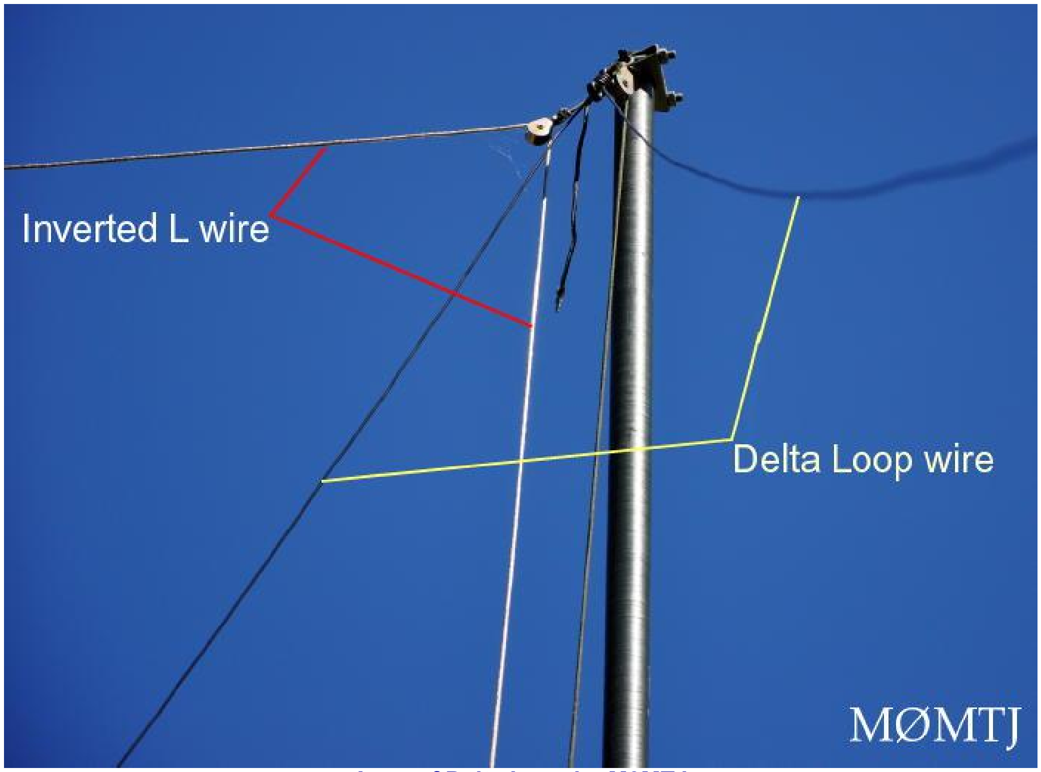
Delta Loop Antenna - Tuned for the 17 metre band but also usable as a multi-band operation



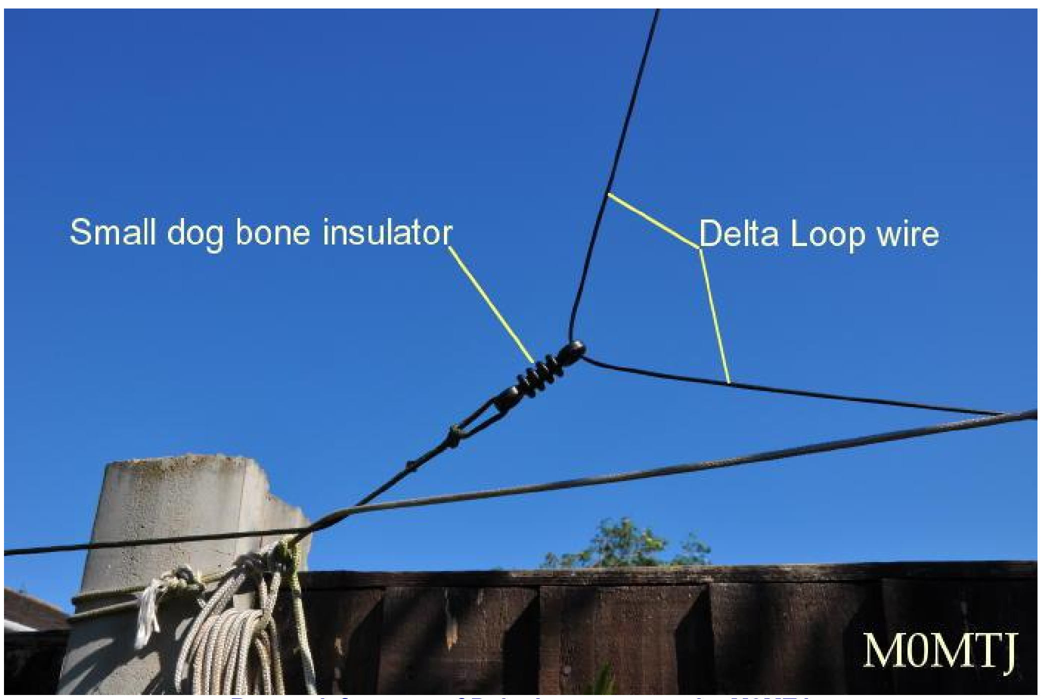
A typical Delta Loop antenna - diagram by W5SDC - gives multi-band operation with minimal cost.
My Delta Loop is fed near the bottom corner - it cannot be fed at the top, as in the diagram above, due to unwanted interaction with the antenna wire of the Inverted L antenna which is supported on the same pole.

My Delta Loop is fed near the bottom at one corner - it cannot be fed at the top, as in the diagram above, due to unwanted interaction with the antenna wire of the Inverted L antenna which is supported on the same pole.

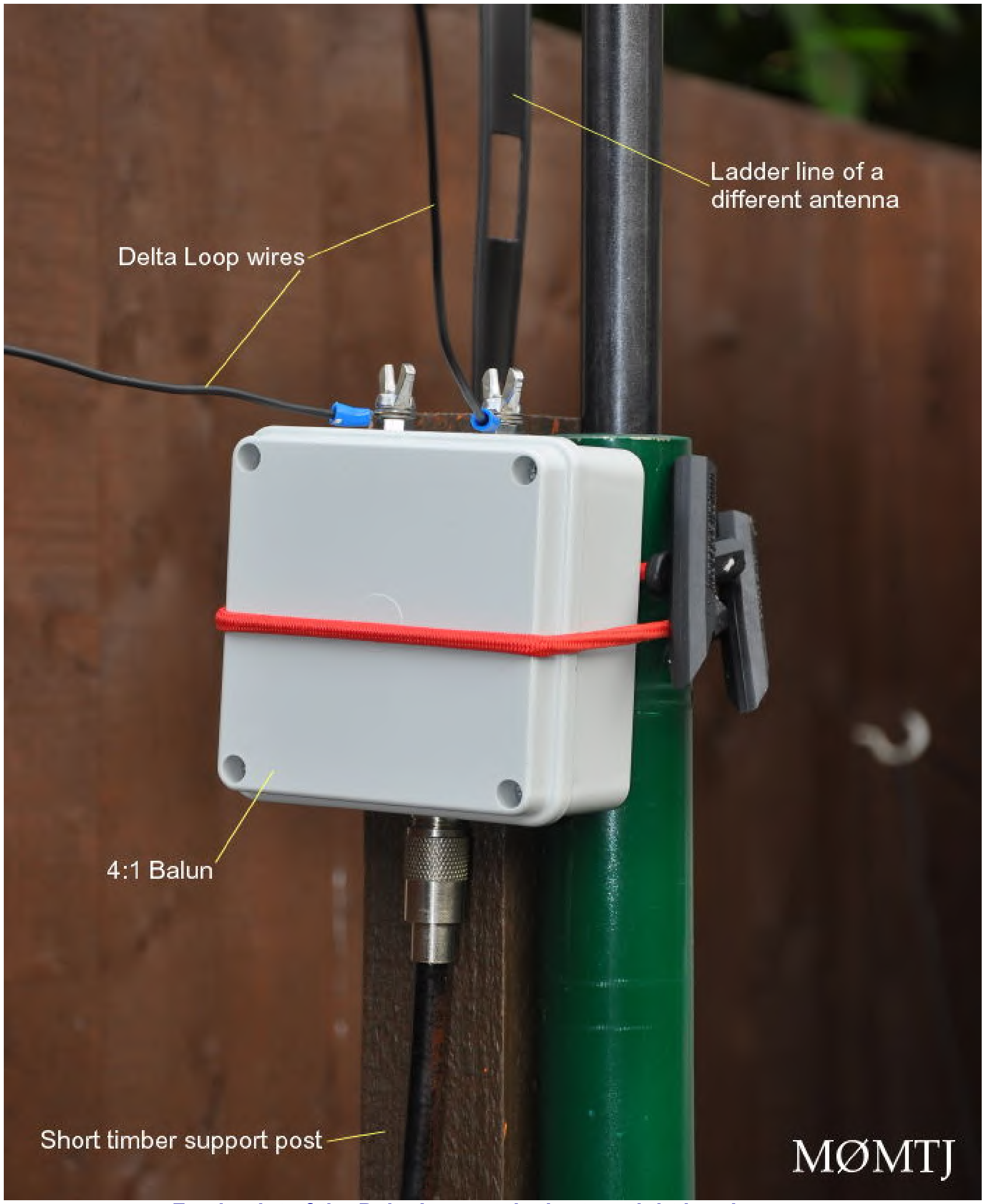
It consists of a 16 metre long loop of wire in triangular Delta shape, hung from the top of the pole supporting the inverted L antenna and fed via RG213 coaxial cable via a home-brew 4:1 balun. A loop is really a single band antenna cut for one wavelength on the band of interest, however it can also work on higher bands with an ATU - as a good, cheap and easy to install multi-band H.F. aerial. Performance is a little better than the inverted L on the higher bands, but on 10 metres the tuned 10 / 6 metre wire 'fan' dipole in the loft can still be better.



Apex of Delta Loop by M0MTJ



Bottom left corner of Delta Loop antenna by M0MTJ



Feed point of the Delta Loop at the bottom right hand corner

The Feed Point of the Delta Loop Antenna is at the bottom right hand corner
The Antenna is fed via a 'home brew' 4:1 balun by M0MTJ

Below are the VSWR measurements for the 16 metre long loop which has been measured an cut for resonance in the 17 metre band. For comparison are the measurements for the 12 metre long loop (which has not been optimised) and an 18 metre long loop which is of arbitrary length:

16 metre long loop of wire for the 17 Metre Band (optimised for 17m band)		
BAND	VSWR	VSWR
20m	14.0 MHz = 6.5	14.35 MHz = 4.9
17m	18.07 MHz = 1.2	18.16 MHz = 1.2
15m	21.0 MHz = 3.1	21.45 MHz = 3.7
12m	24.8 MHz = 5.9	25.9 MHz = 6.1
10m	28.0 MHz = 4.1	29.5 MHz = 4.4

12 metre long loop of wire for the 12 Metre Band (NOT optimised)		
BAND	VSWR	VSWR
20m	14.0 MHz = 22.1	14.35 MHz = 21.1
17m	18.07 MHz = 8.4	18.16 MHz = 8.1
15m	21.0 MHz = 5.0	21.45 MHz = 4.6
12m	24.8 MHz = 1.9	25.9 MHz = 2.0
10m	28.0 MHz = 5.0	29.5 MHz = 6.1

18 metre long loop of wire (An arbitary length between 20m & 17m)		
BAND	VSWR	VSWR
20m	14.0 MHz = 2.1	14.35 MHz = 1.4

17m	18.07 MHz = 2.6	18.16 MHz = 2.5
15m	21.0 MHz = 6.8	21.45 MHz = 8.4
12m	24.8 MHz = 6.3	25.9 MHz = 6.5
10m	28.0 MHz = 2.9	29.5 MHz = 2.5

Many users claim that loop aerials are quieter than typical vertical antennas. There are many plans available in the internet and given a suitable support or pole and a 4:1 balun it can take only a few minutes to install a loop antenna.

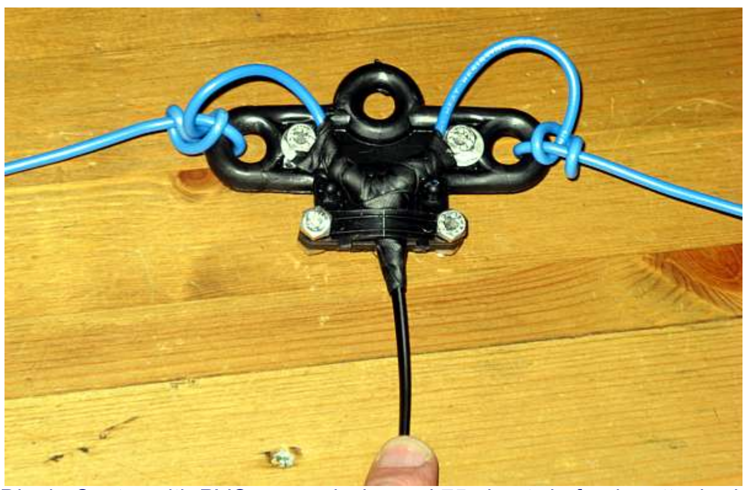
Arthur M0PLK (SQ2PLK) at Ham Radio Shop supplies an interesting lightweight self supporting Delta Loop antenna: http://ham-radio.urbasket.eu - see the review on the Polonia DX Award here: http://pdxa.one.pl/articles.php?article_id=17

LOOP ANTENNA LINKS: See lots more links to Loop Antennas on my links page here

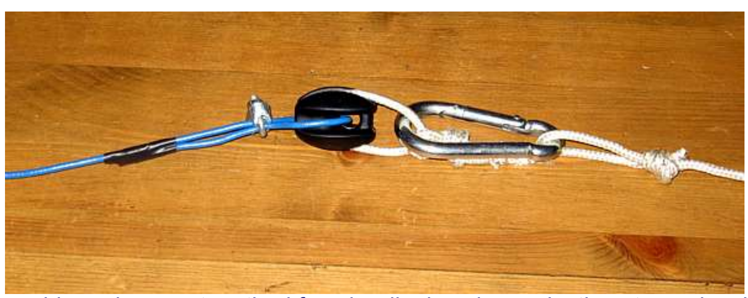
Dipole or Doublet Antenna for 20m and 10m

This is an antenna trapped dipole for 20m and 10m. Currently it is fed by 75 ohm twin feeder to a 1:1 balun in the loft, then on to the ATU (AMU) via a short RG213 coaxial cable. Although it was initially installed horizontally, it is now installed with one leg supported vertically on a 7 metre fibreglass 'Sota' pole with the other leg supported horizontally about 2 metres above the ground. This is a rather unorthodox arrangement for a balanced dipole, but it seems to work ok and was inspired by another radio amateur's idea - although I don't recommend balanced feeder for this arrangement!

It looks much neater than the horizontally strung dipole and offers a more omnidirectional radiation pattern too.



Dipole Centre with PVC covered wire and 75 ohm twin feeder attached.



Removable end support method for wire dipole using a plastic antenna insulator, snap-hook and Dacron rope.

Photo showing how the wooden support posts are held in the ground by the steel Met Post.
This Met Post and wooden pole now supports the 7 metre high fibreglass Sota Pole (fishing pole).

The 'deformed dipole'.

A Dipole for 20m and 10m.

One leg is vertical, giving a more omnidirectional pattern and supported by the 7 metre long fibreglass fishing pole, while the other leg runs off horizontally at about 2 metres above the ground.

This antenna is fed by 75 ohm twin feeder.

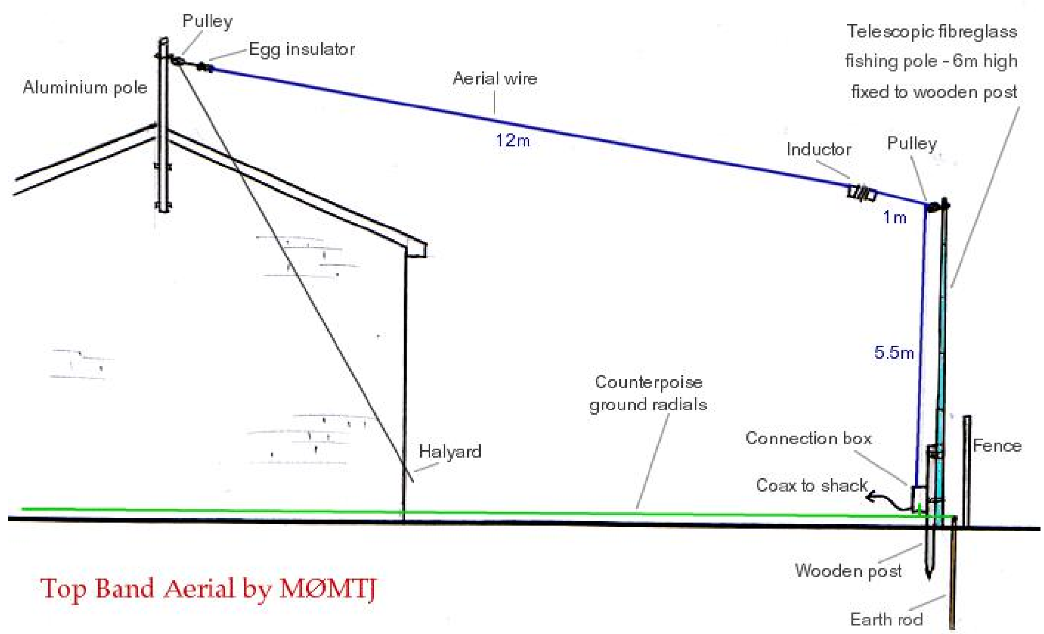
The Deformed Dipole

Compact Antenna for Top Band

A Shortened Inverted L for 160 Metres

Despite the dreadful noise on top band caused by modern electronic gadgets and the difficulty in accommodating a necessarily large aerial in a small garden, I was keen to try to get on to top band. I experimented with some different ideas during 2009, some of which are shown on this page.

Eventually I settled on the design shown below. It is an Inverted L type aerial, shortened by the use of a loading coil. It uses a fibreglass telescopic fishing pole to allow it to be easily lowered out of sight when not in use. Read more on Antennas page 2 here>



Shortened Base Loaded Top Band Antenna For Small Gardens uses a fibreglass telescopic fishing pole to allow it to be easily lowered out of sight when not in use.

Read more about Top Band Antennas on Antennas page 2 >

Other Antennas:

End Fed Zepp Antennas for 20m / 17m and 15m :

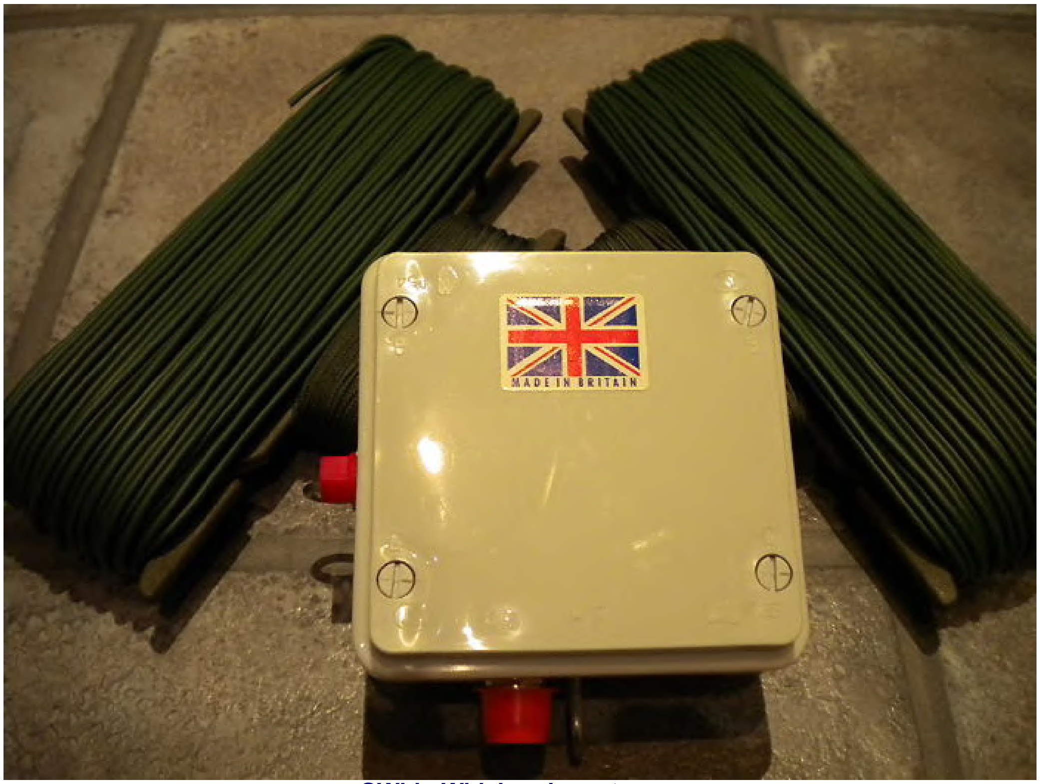
High quality commercially built Zepp antenna from G Whip Antenna Products.
http://www.gwhip.co.uk/

Above is a high efficiency, high quality commercially built Zepp style antenna using a half wave radiator. However there is a difference - unlike the traditional Zepp antennas, G4ICD's design dispenses with the long trailing 1/4 wave twin feeder matching section and counterpoise and, instead, uses a G-Whip's helical tuned unit.

The end fed Zepp is extremely versatile - it can simply be hung from the fascia board or guttering just outside one's window: The 1/2 wave wire radiator made of high strength Kevlar is easily sloped down the garden and is a camouflage green in colour so as to be almost invisible. The G-Whip Zepp is supplied with a fascia board insulator, a throwing line with plus cable strain relief and fittings, the IP65 waterproof resin potted box fitted with UHF connectors (SO239) for coax feeder. The Zepp can be mounted vertically (e.g. using a telescopic fibreglass pole), horizontally or sloping and can be ready in a matter of minutes.

I then decided to try an excellent new design developed by Geoff G4ICD - an End Fed Zepp antenna with a difference. The G-Whip End Fed Zepps are high efficiency, resonant mono band antennas utilising a half wave radiator, however this new G-Whip design by G4ICD dispenses with the long trailing 1/4 wave twin feeder matching section and counterpoise and, instead, uses a helical tuned unit. Using versions for 20m, 17m and 15m will enable me to get on the air with the minimum of fuss since the G-Whip end fed Zepp can simply be hung from the facia board or guttering just outside one's window. The high-strength Kevlar, camouflage green 1/2 wave wire radiator is easily sloped down the garden to be almost invisible.

G-Whip Widebander :



GWhip Widebander antenna.

Using the popular idea of feeding a large but non resonant antenna with an impedance converting 9:1 unun.

The G Whip wideband antenna consists of a 9:1 unun of GWhip's customary high quality for best efficiency, two 20metre lengths of kevlar wire for the radiator and counterpoise which provide operation from 3.6MHz to 50MHz. Feed with good quality low loss coax and use an ATU to match. The 20 metre radiator wire can be used as a sloper, or supported by convenient supports such as poles or trees in a straight line or 'dog legged'. I use a shorter radiator wire run up a telescopic fibreglass pole for operation on 20 metres an above.

Dual Band J-Pole :

There is a dual band vertical J-Pole antenna in the loft as a back up for the 2m and 70cm bands.

The excellent Dual Band N9TAX Slim Jim antenna that I use in the loft as a reserve antenna.
More information from Joe N9TAX at: www.n9tax.com
www.ebay.co.uk/itm/VHF-UHF-Slim-Jim-J-Pole-Dual-Band-2m-70cm-Antenna-jpole

Previous Antenna installations:

(2011 - 2013)

1) A trapped Inverted L for 80m and 40m with an SGC-230 auto antenna coupler at its feed-point at the bottom of the garden. RG213 coaxial cable is used to feed the output of the auto-coupler back to the shack. This can be used on all bands from 160 through to 10 metres. The support post is installed at the bottom of the garden with the end of the antenna wire being supported by Dacron rope that is attached to a pulley on a pole at the apex of the roof. A simple, single sloping wire element provides use on the 17 metre band. Although too short to be really effective on 160 metres, Top Band can be tuned by the SGC coupler. A pretty good all-round antenna. more

2) A half wave Wire J-Pole fixed to a telescopic fibreglass fishing pole for 10m. Cheap and effective. more about J-Poles

3) A 'home-brew' omnidirectional, vertical dual band, end fed antenna for 2 metres and 70cm. This is of the Controlled Feeder Radiation design (CFR) by VK2ZOI; effectively an end fed half wave dipole on 2m with an aluminium sleeve to achieve 70cms with a few extra dB's of gain. It is mounted on an aluminium mast 10 metres a.g.l. more

4) A DK7ZB design dual band Yagi antenna, with 5 elements for 2 metres and 8 elements for 70cms, mounted horizontally for SSB. A lightweight antenna rotator is employed and uses a push-up telescopic mast. Height above ground level is again approximately 7 metres. The DK7ZB is an excellent twin band Yagi antenna. more

5) Dual Band Fan Dipole, made from thick loudspeaker wire, mounted horizontally in the loft space for 10 meters an 6 metres. Cheap & effective.

6) (Installed late September 2013) Wire J-Pole antenna for 4 Metres (70 MHz) supported on a 3 metre long telescopic fibreglass pole to be attached to the top of the aluminium push up mast that supports the DK7ZB dual band yagi and rotator,

Other Options that can be deployed on an 'as required basis':

7) Compact Loaded Top Band Antenna, based on a design idea by Stuart Craigen G4GTX more

8 & 9) G Whip End Fed Zepps (EFZ's) for either 20m, 15m or 17m or the G-Whip "WideBander" which is an 'UnTenna' style antenna that can be used for 20m through to 10m using good quality G Whip 9:1 UnUn; useful additions for antenna flexibility. more

10) N9TAX Dual Band Slim Jim (J-Pole) antenna mounted in the loft as a back-up antenna for 2m and 70cms. Very good. more

11) Delta Loop Antenna - 16 metre loop of wire in triangular Delta shape, hung from the top of the pole supporting the inverted L antenna and fed via RG213 coaxial cable via a 4:1 balun. The loop is really a single band antenna cut for one wavelength on the band of interest, however it also can be pressed into service for some higher bands - a good, cheap and easy to install aerial; Often works better than the inverted L on the higher bands, but on 10 metres the tuned 10 metre dipole in the loft is sometimes better. more

(2011)

In mid 2011 I experimented with an excellent N9TAX designed dual band Slim-Jim (J-Pole) antenna for 2m and 70cms. This is made from lightweight 450 Ohm ladder line which can be fixed to the top of a 10m tall fibreglass, telescopic, fishing pole. The N9TAX works extremely well indeed. More information from Joe N9TAX at: www.n9tax.com and buy at: www.ebay.co.uk/itm/VHF-UHF-Slim-Jim-J-Pole-Dual-Band-2m-70cm-Antenna-jpole

N.B. I tried to home-brew the DJB-1 dual band J-Pole antenna using plans published by the ARRL in QST magazine. I wanted a neat antenna that could be enclosed in a protective tube to minimise weathering effects. However trying to tune this antenna at UHF frequencies proved to be frustratingly difficult to do and after two full days work I could not get the thing resonate accurately at the correct frequency. Sadly, for this reason, I cannot recommend the Dual Band J-Pole as a home-brew project.

The N9TAX antenna on the other hand works very well. However it cannot be enclosed in a tube due to the velocity factor effect de-tuning the antenna's resonant frequencies.

(Late 2011)

Due to difficulties with the stability of a lightweight fishing pole as a support I moved back to using the lightweight aluminium telescopic mast, with stays, to support a Watson W-50 vertical dual band collinear for 2 metres and 70 cms FM.

The excellent N9TAX dual band Slim Jim is now installed in the loft.

(Antennas used up until 2010)

1) A trapped Inverted L for 80m and 40m fed by RG213 coaxial cable to the LDG Z-11 Pro antenna matching unit in the shack. This can be used on all bands from 80 through to 10 metres. The support post is installed at the bottom of the garden with the end of the antenna wire being supported by Dacron rope that is attached to a pulley on a pole at the apex of the roof. This excellent antenna is still use. more

2) A trapped dipole for 20m and 10m. This was fed by 75 ohm twin feeder to a 1:1 balun then on to the AMU via RG213 coaxial cable. It was initially installed horizontally, but more latterly installed with one leg supported vertically on a 7 metre fibreglass 'Sota' pole with the other leg supported horizontally about 2 metres above the ground. A rather unorthodox arrangement for a balanced dipole, but it seemed to work ok, it looked much neater than a horizontally slung dipole and also offered a more omnidirectional radiation pattern. more

4) A compact Inverted L for the 160 metre band - Top Band - shortened with a loading coil. more

5) As N9TAX Dual Band Slim Jim (J-Pole) antenna for 2m and 70cms. This was fixed near the top of a 10m telescopic fibreglass fishing pole that I pushed up whenever it was required. more

(2008)

W-2000 - Vertical Collinear mounted on a temporary 10m telescopic pole:

I no longer have the Watson W-2000 but this is how it was used previously:

The Watson W-2000 covered VHF (2 metres / 144 MHz) and UHF (70 cms / 430 MHz) and also, rather usefully, 6 metres (50 MHz) too. The W-2000 is 2.5 metres long and enclosed in white fibreglass with three radial elements at the base.

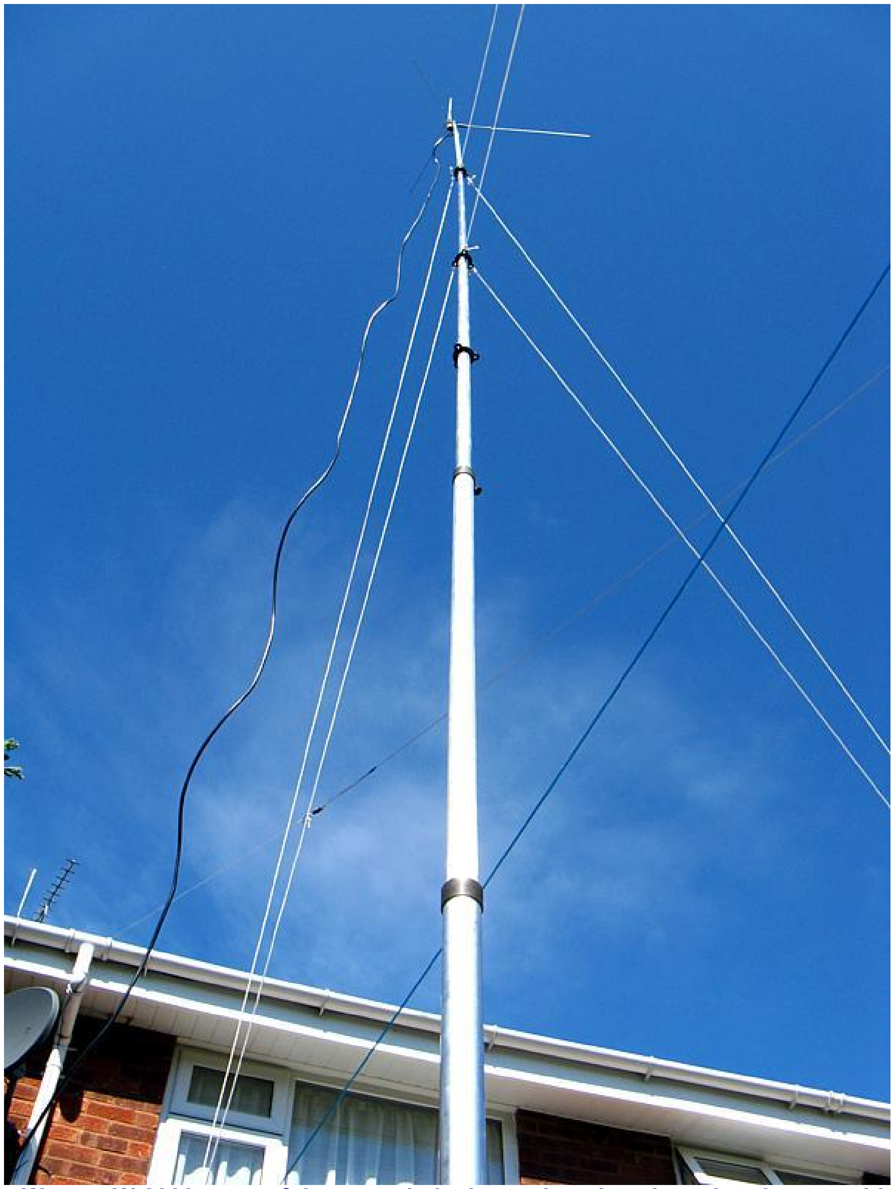
Unfortunately I had nowhere practical to install a separate mast for the VHF / UHF antenna, so this was mounted on top of a 30 foot (10 metre) high telescopic aluminium mast in the back garden. The base of the mast was placed in a handy metal sleeved hole that was already present in a small wall in the garden. Very fortunate indeed!

The antenna is connected to the radio via the very low loss Westflex 103 coaxial cable. The cable was left in place permanently, running from the shack in the front bedroom, up into the loft and out of a small hole in the back of the house, down a drain pipe into the back garden. From there the aerial can be connected as an when required:

When VHF or UHF operation is required I have to connect the coaxial cable to the Watson W-2000, fix it to the top of the telescopic mast, which is very quick using two V bolts and 4 wing nuts, put the mast in the hole and raise it to a good height. I tend to extend it so that the bottom of the antenna is at about 24 feet in the air, the height of the apex of the house, so it is in fairly clear space.

A VHF and UHF aerial needs to be as high as possible since at these frequencies communication is essentially local and 'line of sight' - unless heightened propagation conditions, such as Sporadic E or a Temperature Inversion is prevailing at the time.

Even at 24 feet the mast is rather wobbly, so it was tied down using three nylon guy ropes.



The Watson W-2000 on to of the extended telescopic pole - about 8 or 9 metres high.

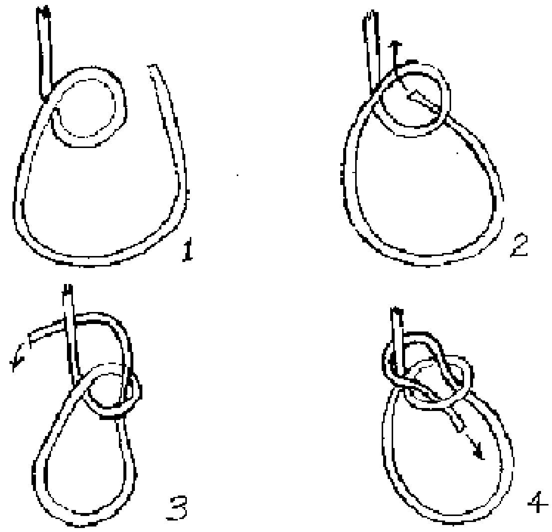
Photograph of a Watson W-2000 on Telescopic Mast at the lowest position.

MORE ANTENNAS

Our good friend in Australia Felix Scerri, VK4FUQ, uses Inverted V antennas but also highly recommends the Quad Loop style antenna for HF work. These are well worth investigating, and you can read more here: Antennas 3 with more antenna ideas on Antennas 2 and Antennas 4 and the Links Page here and here

KNOTS FOR SECURING WIRE ANTENNAS

I have found the Bowline to be one of the most useful, it is strong and easy to tie. A Bowline will not slip in any circumstances and, usefully, the more load that is put on it, the tighter it gets. Read more about good knots for amateur radio aerials here...



The Bowline Knot - Read more about knots here ...

Antenna Trimming Chart and useful Antenna Rigging Accessory ideas

On Antennas 4 I have included a helpful Antenna Trimming Chart and some useful ideas for Antenna Rigging Accessories

More project ideas here>

73

Mike, M0MTJ 2011 / 2012

Antennas 2 | **Antennas 3** | **Antennas 4** | **Antennas 5** | **Antennas 6**

Links to further reading:

Introducing The All Band Doublet: http://www.cebik.com/content/edu/edu6.html ***N.B. Create a free account at*** http://www.cebik.com

The All Band Doublet - http://www.cebik.com/wire/abd.html

The ALL Band HF Doublet on Ham Universe - http://www.hamuniverse.com/hfdoublet.html

Multi Band Dipoles Compared - by ARRL on QST and DX Zone:
http://www.arrl.org/tis/info/pdf/9611073.pdf http://www.dxzone.com/cgi-bin/dir/jump2.cgi?ID=7499

PDF Document - The W3DZZ Antenna -
http://www.users.icscotland.net/~len.paget/GM0ONX%20trap%20dipole.pdf (**!!! But don't use coaxial cable with a 'choke balun' at the centre of the dipole! Use twin feeder with the Choke Balun at the other end. Less power loss.!!!***)

See Practical Dipole Antennas Compared: http://www.qsl.net/ta1dx/amator/practical_dipole_antenna.htm

Practical Antenna For 160 Metres - http://www.iw5edi.com/ham-radio/?a-practical-antenna-for-160-metres,32
http://www.ik1mnj.net/id202.htm

More:

The website of GM0ONX http://www.gm0onx.co.uk/

The Inverted L - PDF document: http://www.users.icscotland.net/~len.paget/5%20band%20Inverted%20L.pdf

Adding Top Band To The Inverted L - PDF Document:
http://www.users.icscotland.net/~len.paget/Inverted%20L%20adding%20top%20band.pdf

The All Band Inverted L - http://www.antennex.com/preview/archive3/ltv.htm

Q.T.H. Move in 2010 !%*?"*!?!

We decided that we'd like to move house in 2009, we found a new property in early 2010. My amateur radio aerials were duly taken down and the ham shack packed away. However after months of delays we still had not moved by August 2010, but we were still hoping to move. However after months of messing about and stringing us along our buyer pulled out the very day before we were to exchange contracts later in August 2010.

This cost us a lot of time and a great deal of wasted money. Thank you Mrs xxxxxx :-(

After a wasted year we decided to stay where we were and take the house of the market. Instead we spent the next eight months remodelling and redecorating. No time for playing radio of course and besides everything was still all packed away in boxes!

In mid 2011 I was getting frustrated that I had no radio. So I suppose it's time to think about re-establishing the station and to start planning the installation of some antennas. Of course Jules, my XYL, understandably questions my antennas and experiments!

Due to time constraints I will probably start again with a somewhat temporary antenna. I was thinking along the lines of an "Untenna" - so I installed a 7.2 ish long wire supported on a vertical fibreglass pole with a horizontal 'counterpoise' connected via a 9:1 balun to the coax back to the shack. Of course it is a fairly low efficiency multi-band (wideband) antenna, but easy to get going quickly. The GWhip Widebander antenna by Geoff Brown G4ICD is possibly the highest quality antenna of this type available, using a very high efficiency, top quality 9:1 UnUn with a 17 meter wire radiator and 10 metre long counterpoise - a very useful, versatile 'all situations' antenna.

As time progressed I re-established my full size trapped Inverted L antenna for 80metres and 40 metres and added a switchable loading coil at its base for use on 160 meters, as described above.

Then I gradually re-established the 2 metres and 70 cms antennas with the vertical W-50 and horizontal dual band DK7ZB Yagi - as detailed above.

Antennas 2 | Antennas 3 | Antennas 4 | Antennas 5 | Antennas 6

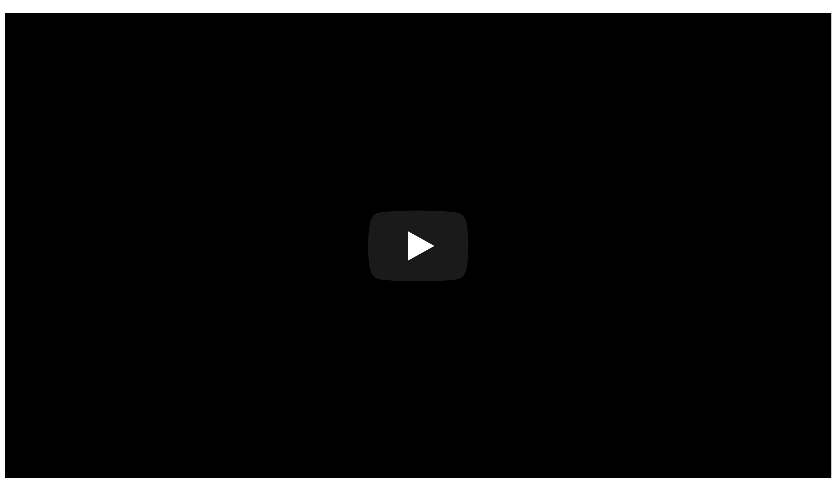
Index To Other Antenna Pages:

G-WHIP G Pro Whip antennas
http://www.gwhip.co.uk/

http://www.gwhip.co.uk/

Just For Fun:

A tower that we may like to have to attach our antennas to - but I don't think that Health And Safety was taken into account here:



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AERIALS (ANTENNAS) 5

Antennas 1 | **Antennas 2** | **Antennas 3** | **Antennas 4** | **Antennas 6** | **Antennas 7**

The VK2ZOI "Flowerpot Antenna" - A physically end fed Half Wave "Coaxial Dipole" for 2 metres and 70 centimetres

For 2m and 70cm FM I use a mounted on a lightweight aluminium telescopic pole on the apex of the hose. The base of the antenna (the bottom of its radiating element) is approximately 11 metres above ground level. This antenna is based on the Controlled Feeder Radiation principle (CFR) and is described by VK2ZOI on his website. Also known as a "Coaxial Dipole". My version is described below.

Also seen in the photograph are the ropes that support the H.F. wire aerials.

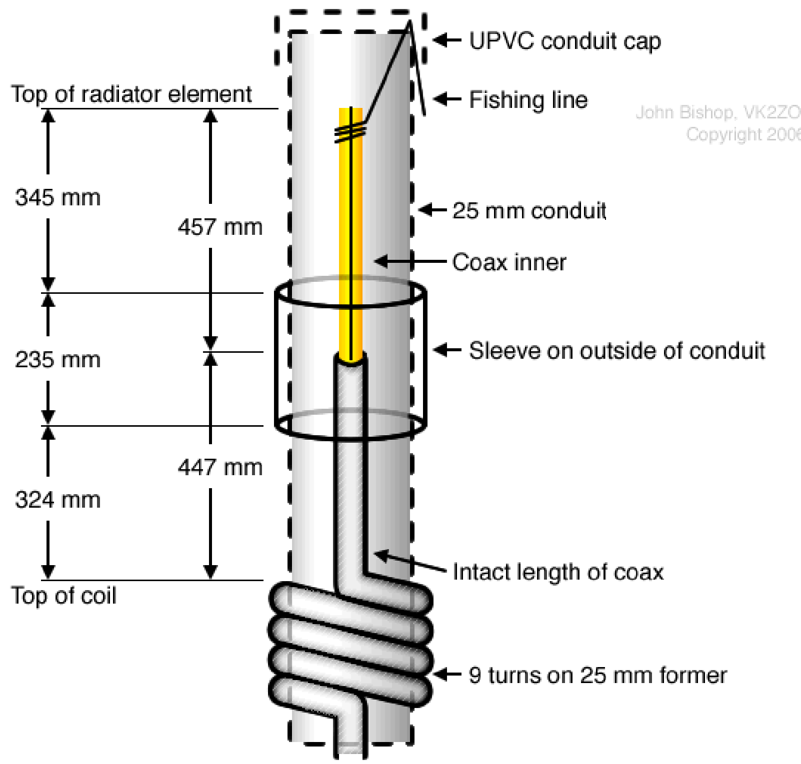
Home brew dual band vertical antenna for 2 metres and 70 cms
(Coaxial Dipole / Controlled Feeder Radiation Antenna / 'Flowerpot Antenna')

VK2ZOI has produced some extremely interesting and potentially very useful dipole antenna designs. The designs could form the basis for a great home-brew antenna project since it is physically end fed and can also be made into a dual band aerial for 2 metres and 70 centimetres, so forming the basis of a viable alternative to buying an expensive commercially manufactured 'white stick' antenna.

The final dual band version works very well and can form the basis of a viable alternative to commercially made 'white stick' antennas, because there's nothing better than using your own home-brew antenna!

Physically, the feeder cable enters the antenna at the bottom end, so it looks like an end fed aerial. VK3TWO / VK6TWO describes it as a "Coaxial Dipole". 'Electrically' it is a simple dipole. The RF is travelling 'inside' the bottom 'element' and doesn't 'feed' the antenna until where the coax is cut - in the centre of the antenna, as shown in the diagram below. Where the outer braid is cut (electrically the centre feed point), the RF then radiates like a simple dipole, via the top radiator (coax core), and via the outside of the coax - the bottom half of the dipole. The top radiator is thinner than the lower radiator (hence why the lower radiator is slightly shorter than the upper radiator).

The coiling of the coax is simply forming an RF choke (high impedance point), to stop the RF continuing down the outside of the braid, thus electrically it 'appears' to be the end of the radiating element.



http://vk2zoi.com/articles/half-wave-flower-pot/

I purchased a 3 metre length of 25mm diameter conduit from B&Q, our local DIY centre and ordered some 25mm end caps and heatshrink from ebay. I already had some good quality RG58 for the feeder and main 2 metre radiating element and some aluminium foil for the 70cm sleeve dipole.

First of all I cut the RG58 cable to form the 2m radiating section and choke coil. Because the UK's 2m allocation of 144 to 146 MHz is narrower than the 144 to 148 MHz available in Australia, I varied slightly from the design shown. The centre of the UK's 2m band is about 1% longer in wavelength, so I decided to make both the top and bottom measurements 1% longer.

I therefore stripped 460 mm of the outer sheath and braid from the cable to form the top 1/4 wave element of the dipole. I then measured down 450 mm and marked the point where the lower 1/4 wave element would finish and the choke coil would start.

Next I attached a thin nylon cord to the top of the top radiator, the coax inner.

I then cut the 3 meter length of 25 mm conduit down to about 2.3 metres and drilled a hole where the coil would start, wound 9 turns of RG58 cable from that hole and marked the position of the lower hole. I then removed the coaxial cable and drilled the second, lower, hole.

I then pushed the radiating section of RG58 into the top hole and fed it up towards the top of the tube, stopping when the marker tape reached the hole. I then wound the coil and pushed the remainder of the RG58 through to lower hole and fitted a PL259 plug on the end.

I pulled the top of the radiator wire tight using the nylon cord and pushed the end cap on. The antenna was then ready to be tested on the 2 metre band. I found that the resonant frequency was rather too high, just above 146 MHz, so I pushed an additional 10 mm of coaxial cable into the upper section of the tube - therefore making the lower 1/4 wave section of the dipole 460 mm long - the same as the top section. I tightened up the choke coil winding again and performed another test.

This time the resonant point was just over 145.000 MHz - near enough the centre if the UK's 2 metre band. That was perfect, so the 70 cm sleeve element was then added - this is a 235 mm long tube of kitchen foil positioned exactly at the centre (feed) point of the 2 meter dipole within the tube.

The SWR was tested and found to be acceptable across both the 2m and 70cm bands.

I then fitted the end cap, applied the heatshrink to the coil and to the aluminium foil sleeve. I noticed that when the antenna tube was moved around the cable inside rattled around making a noise that may be rather annoying to anyone near its final location.

To help hold prevent the cable from rattling I pushed up 4 or 5 small pieces of foam material up the tube from the bottom to rest at various positions along its length. With these pieces in place the cable was certainly silenced, however it may have had a deleterious effect on the SWR.

With the antenna now in its finished physical state I naturally checked the SWR again to compare against the performance in its semi-complete state. I was pleased to find that the SWR was still fine across the 2m band, in fact the SWR was a little lower. However the SWR at the edges of the 70cm band was considerably higher - 1.8 at 440 MHz and about 2.2 at 430 MHz.

I conjectured that the heatshrink covering the foil sleeve dipole may have caused the change in response so I removed it, but the SWR was little different and the bandwidth on 70cm was now disappointingly narrower than expected and hoped for.

Although I cannot say for certain, because they cannot now be easily removed, but it may be possible that the pieces of foam may be the culprits for the difference.

While the bandwidth could not be improved, I decided to move the centre point of resonance down a little by increasing the length of the sleeve element from 235 mm to 245 mm. With that adjustment the SWR was now approximately 1.6 at 430 MHz but rising to 2.0 at 440 MHz. (Unfortunately I forgot to note the exact figures down in all cases).

When the antenna was connected to the 20 meter length of Westflex-103 back to the shack, the SWR reading were as follows:

2 Metres - SWR		70cms - SWR	
144.00	1.3	430.00	1.2
144.50	1.2	431.00	1.4
145.00	1.2	432.00	1.4
145.50	1.2	433.40	1.0
146.00	1.2	434.00	1.3
		435.00	1.8
		436.00	1.6
		437.00	1.0
		438.00	1.5
		439.00	2.0
		440.00	2.1

The SWR readings in the shack for 2 meters are lower than at the feed point, which is presumably due the losses in the feeder. The SWR readings for 70 cms look rather erratic, with a strange peak at 435 MHz, while the 430 MHz figure is lower than at the feed point of the antenna, and the 439 and 440 MHz figures are disappointingly higher than hoped for. The peculiar readings are likely due to feeder effects.

However the SWR at 433.4, in the FM simplex portion of the band, is very low.

The completed antenna was mounted to the aluminium mast by utilising brackets of the Watson W50 antenna. The brackets had to be reversed so that the narrower diameter of the 25mm tube could be held in place by the V Bolt, while the circular section that previously fitted over the base of the W50 now slid over the mast, which was coincidentally a similar diameter.

I made a small addition to the design in the form of a second small 150mm length of of the 25 mm conduit glued to a coupler section. This is slid into place at the bottom of the antenna to provide additional weather protection to the joint between the W-103 feeder and the RG58 of the antenna - which itself is covered in self amalgamating tape.

Shown in the table below are some signal comparisons with the Watson W-50 antenna; both were mounted on the same mast in the same position and at a height of approximately 7 metres above ground level. Becuase the S-Meter of the transceiver is not calibrated in absolute values, the figres are for relative comparison only - also bear in mind that a typical S Point represents 6dB - therefore the accuracy of these readings will be coarse and might be considered to be +/- 3dB - that's a rather wide variation.

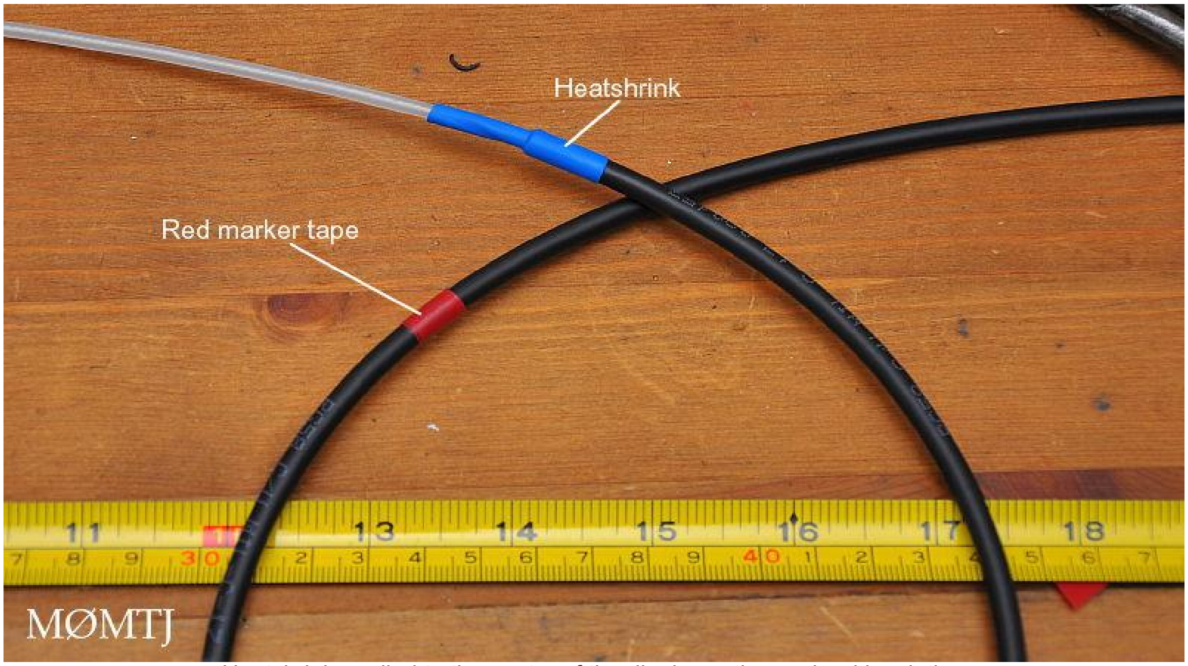
Despite the relative crudeness of these comparisons, the results do seem to indiacte that the VK2ZOI antenna is marginally or slightly better than the W-50 on 2 metres and marginally worse on 70cms. I am quite pleased with this result and beleive that this antenna really could replace the need to buy an expensive commercially manufactured antenna.

My only concern with this type of antenna is that there is no path to ground from the top element, as there would be with a folded dipole or a J-Pole type antenna. This may be a cause for concern as far as static build up is concerned.

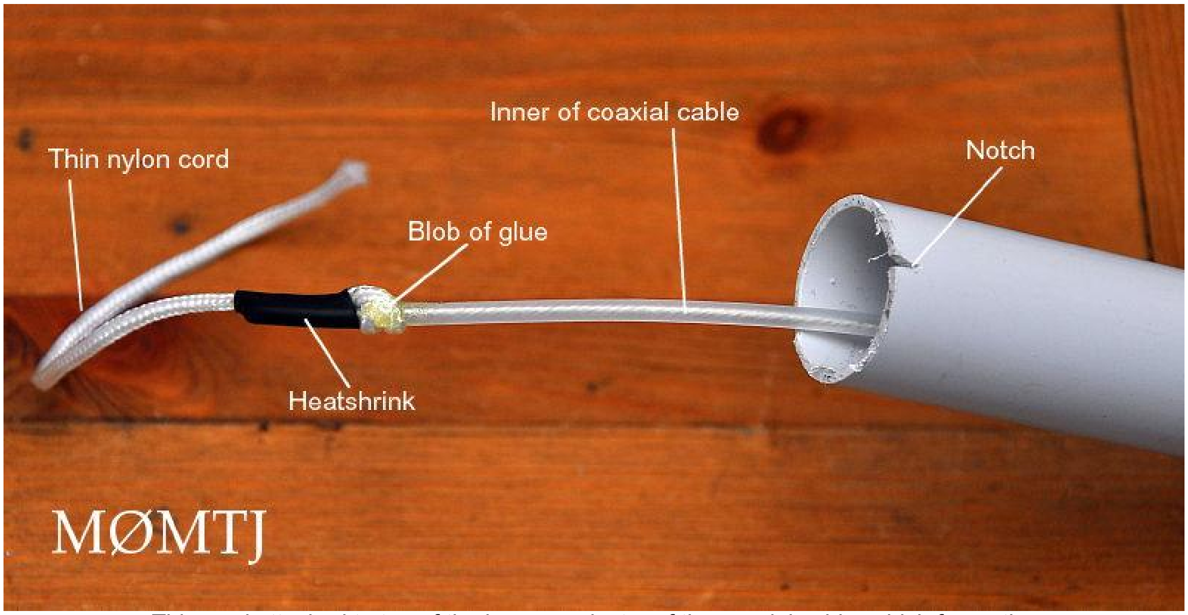
Signal comparisons		
	Watson W-50	"Flowerpot Antenna"
2 Metres		
Station A	S7	S9
Station B	S5	S6
Station C	S4	S4
Station D	S9	S9
Station E	S6	S6
Station F	S0	S1
Station G	S2	S2
Station H	S2	S3
Station I	S6	S6
70 cms		
Station J	S0	S1
Station K	S5	S5
Station L	S5	S4
Station M	S0	S0
Station N	S9	S9
Station O	S6	S6
Station P	S7	S6

Please see the photographs below for a visual explanation of this project. Mike, MØMTJ. 05/03/2013

First stage of construction of the 2m / 70cm dual band antenna
Cutting the 25mm diameter conduit to the desired length and drilling
the two holes allowing the coil to be wound. MØMTJ

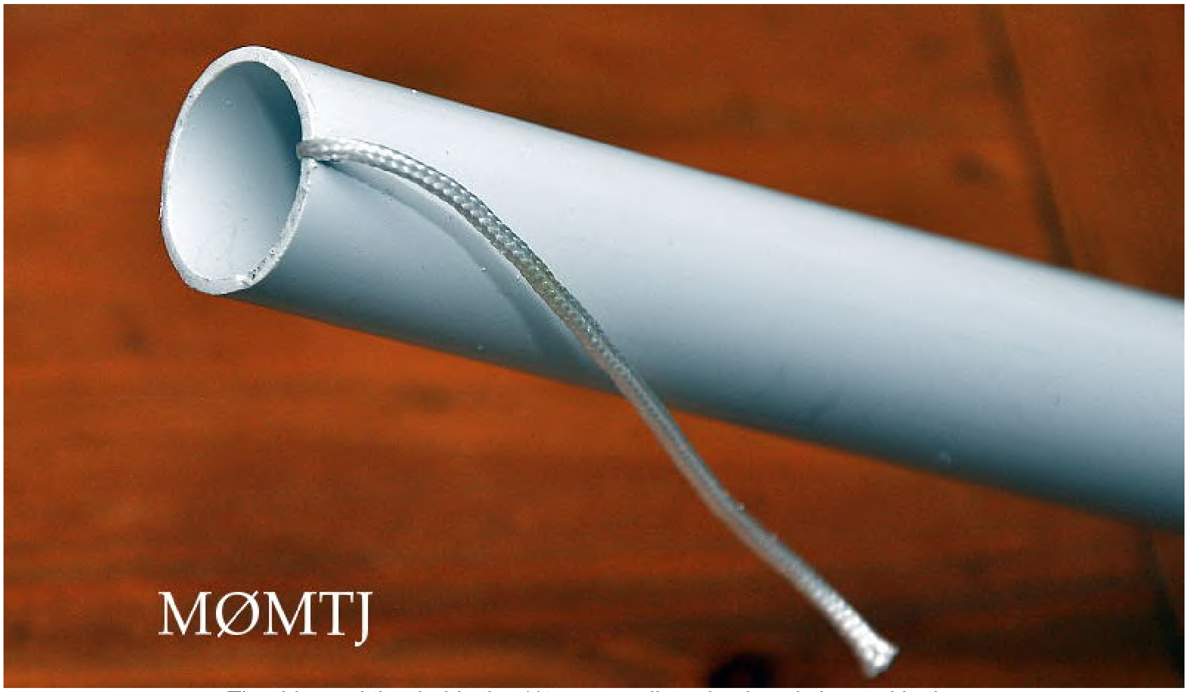


Heatshrink applied to the centre of the dipole section and red insulation tape added to mark the bottom of the dipole where the coil starts. MØMTJ



Thin cord attached to top of the inner conductor of the coaxial cable, which forms the top 1/4 wave section of the dipole with a piece of heatshrink and a blob of glue. MØMTJ

The line isolator choke is formed by winding 9 turns of the RG58 coaxial cable around the 25mm diameter conduit tubing. MØMTJ



The thin cord that holds the 1/4 wave radiator in place is located in the notch and will be trapped in place when the end cap is fitted. MØMTJ

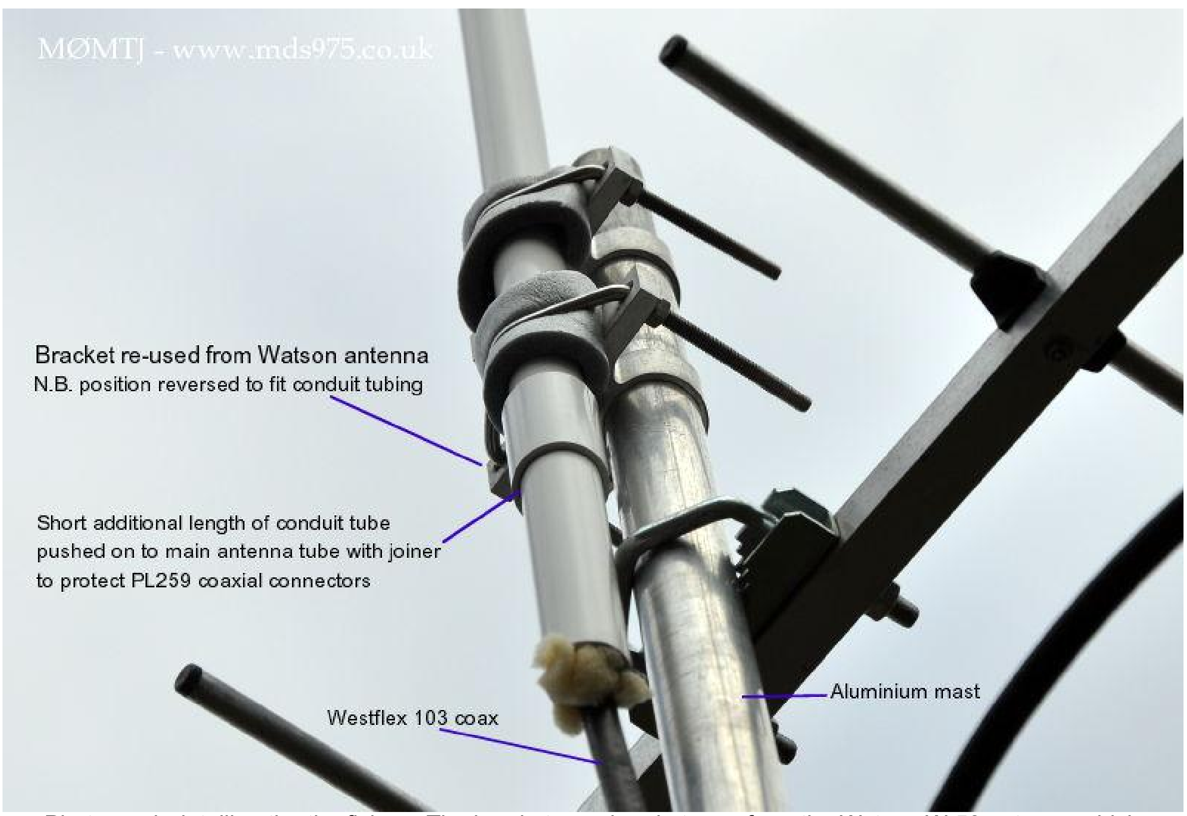
After testing, the coil was covered in heatshrink to prevent water entering the plastic tube.

The foil sleeve dipole for 70cms is covered in heatshrink.

Oops. Lesson learned. When applying heat to the heatshrink I held the tube above the ground and the plastic of the tube started to go soft and bend out of shape. The buckle in the tube can be seen in this photograph.
Lesson: When applying heat, keep the tube flat on the ground or work bench and roll the tube along as the heatshrink shrinks into place ensuring that the tube does not distort or bend.

25 mm end cap sealed in place by heatshrink.

The completed antenna in place, mounted at the top of my aluminium push-up mast. The fixings used are the brackets from the Watson W-50 antenna which have been reversed so that the smaller diameter PVC tube is held in place by the V Bolts.



Photograph detailing the the fixings. The brackets are brackets are from the Watson W-50 antenna which have been reversed so that the smaller diameter PVC tube is held in place by the V Bolts.

For further detailed information and reading, please visit the excellent website of John Bishop VK2ZOI here: http://vk2zoi.com/articles/half-wave-flower-pot/

6 Metre Half Wave Coaxial Dipole - An end fed CFR Dipole antenna supported by a 3 metre long fibreglass fishing pole for 50 MHz

In 2014 I decided to remove the 4 Metre J-Pole antenna from my push-up mast due to the fact that the band is relatively quiet and that I only have the 5 watt Wouxon handheld transceiver for 70 MHz.

I decided that having a good, full size antenna, for the 6 Metre band would be more useful and potentially more rewarding since it can be used with a 100watt HF radio that covers 50 MHz.

The choice of antenna was an easy one. With the great success of the "flowerpot antenna", I decided to build a version for 6 Metres.

Similar designs of Coaxial Dipole antennas had also been featured in recent editions of the RSGB publication RadCom during 2012 and 2013. The antennas in RadCom are described as Controlled Feeder Radiation (C.F.R.) Dipole antennas - the tuned choke at the feed-point controlling, or choking off, the common mode current that would otherwise flow down the outside of the coaxial feeder cable causing E.M.C. issues on transmit, high S.W.R. reduced efficiency and noise on receive. See references below

The advantage of this design is that it can be physically end fed, so there is no feeder cable to route away from the centre of the dipole. Electrically, however, the feed point is at the centre of this dipole aerial, as explained earlier.

Rather than fit the antenna inside a PVC pipe, as with the previous dual band 2m / 70cm antenna described above, I decided to use a lighter weight and less conspicuous 3 metre long fibreglass fishing pole as the support. The completed radiating element simply being taped to the fishing pole.

I cut a length of MIL spec RG58 cable, about 4.5 metres long, to form the bottom half of the radiating section and the choke coil, leaving enough to form a short length (about 30 cm) of cable below the choke coil on to which is soldered a PL259 plug.

The choke consists of 15 turns of the RG58 coaxial cable wound on a 50mm diameter plastic former cut from the empty tube of a cartridge gun that previously contained silicone sealant - allowing a 30cm tail on to which the PL259 plug is fixed on one side and and about 1.31 metre length on the other side that will form part of the radiating element.

The half wave radiator therefore consists of a quarter wave bottom section of the RG58 cable and a quarter wave top section consisting of a length of multi-strand (single conductor) P.V.C. covered antenna wire.

A quarter wavelength at the mid point of the 6 Metre band is: 300 ÷ 51 MHz = 5.88 metres ÷ 4 = 1.47 metres

Due to velocity factor the actual length of the quarter wave sections will be shorter. With the materials that I used, I found that a factor of about 87% was about right, the 1/4 wave length being 1.29 metres.

The top tip of the bottom 1/4 wave section of the coaxial cable is stripped of about 2 cm of outer sheath and braid leaving the length of braided section, measured from where it exits the coil, 129 cm long. The inner conductor is then stripped of 1cm of insulation. This is effectively the centre point of the dipole. To this point is soldered the 129 cm length of the P.V.C. covered aerial wire to form the top half of the antenna. In practice, use a slightly longer length of wire, and then fold over the excess to for the 129 cm length - this can then be used to adjust for lowest SWR at 51 MHz.

The length of the radiating section was therefore about 260 centimetres, plus about 13 centimeters for the coil former giving a total length of 273 cm. This allows about 27 cm of the bottom section of a 3 metre fishing pole to be used to fix to a supporting pole or mount - e.g. to the top of an aluminium mast.

Drill four small holes in the choke former so that when the fishing pole is placed through the centre of the former it can be fixed to the pole using two cable ties.

The radiating section (coax and PVC covered wire) is fixed to the top section of the fishing pole with good quality insulating tape.

The aerial can now be temporarily fixed to the mounting pole using suitable brackets - taking care not to crush the delicate fibreglass! Connect the PL259 plug to the antenna feeder cable using an SO239 back-to-back coupler and test the SWR with an antenna analyzer or SWR bridge. The lowest SWR should be centred on 51MHz and be low - less than 1.5. My reading was 1.2.

If the point of lowest SWR is significantly away from 51 MHz and/or the SWR at the band edges is too high (i.e. over 2) then length of the radiator will need to be adjusted. If the point is too low in frequency, the antenna is too long and will need to be shortened. If the point is too high in frequency, the antenna is too short and will need to be lengthened.

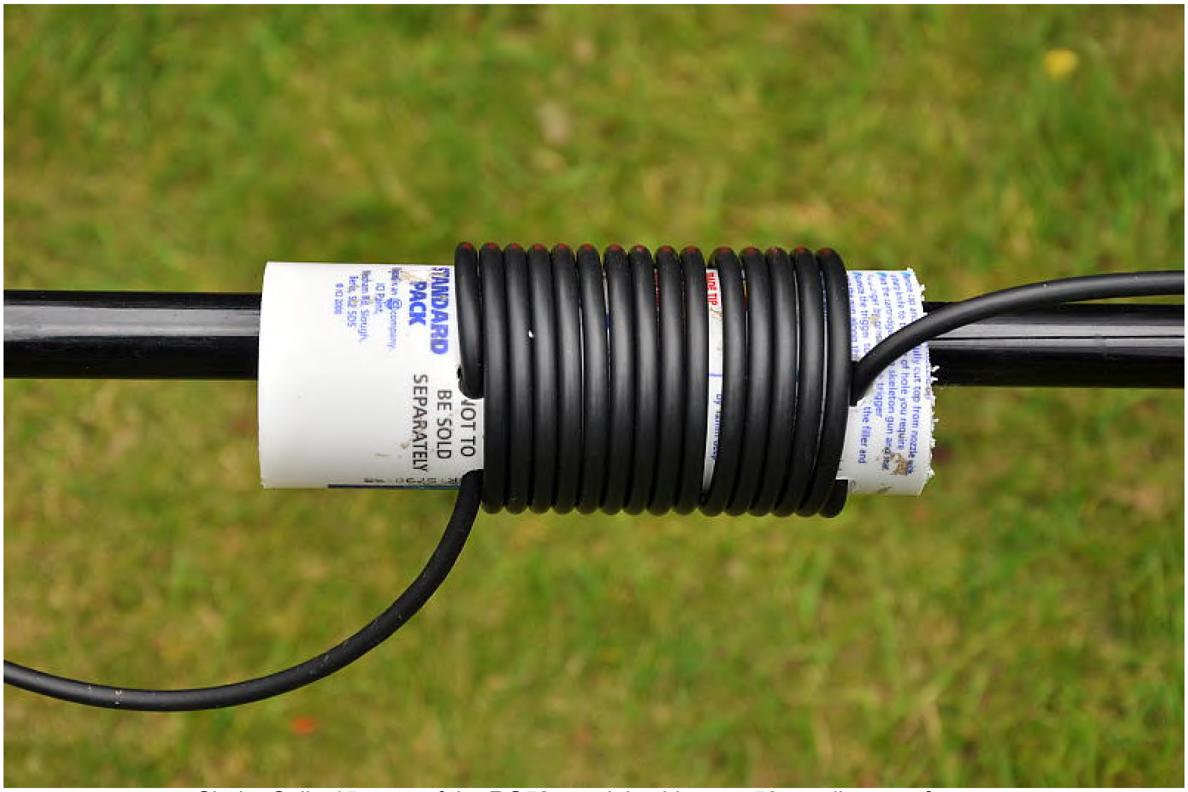
Adjustment can be achieved by pulling the coax through the coil to make it longer, or pushing the coaxial cable back

into the coil to make it shorter. Also ensure that the coil winding are adjusted to that they remain tight and neat. The top PVC covered wire section will also need to be lengthened or shortened accordingly by adjusting the folded over section.

Note that in practice, to obtain the very lowest SWR, the top PVC covered wire section may need to be slightly longer by perhaps 1 or 2 centimetres. This is probably due to the fact that the velocity factor of the PVC covered antenna wire is a little greater than the coaxial cable.

Once the antenna is adjusted correctly, ensure that the wires are securely taped to the fishing pole. Connect the permanent antenna feeder to the aerial using the SO239 coupler and weatherproof the joint thoroughly using self amalgamating tape. Use the very best quality coaxial cable possible to ensure lowest loss. I use Westflex 103, but consider MIL Spec RG8 or RG213 as the minimum standard.

50 MHz Coaxial Dipole / Controlled Feeder Radiation Antenna / 'Flowerpot Antenna'
A physically end fed fed half wave dipole antenna for 6 Metres


Choke Coil - 15 turns of the RG58 coaxial cable on a 50mm diameter former

VHF Band II Broadcast Band antenna for 88 to 108MHz -
Physically end fed, Coaxial Dipole / Controlled Feeder Radiation Antenna (CFR Dipole) for VHF broadcasts

I used a 2 metre long length of 25mm white plastic pipe, strengthened with with a 2 metre length of 21.5mm overflow pipe pushed up the inside.

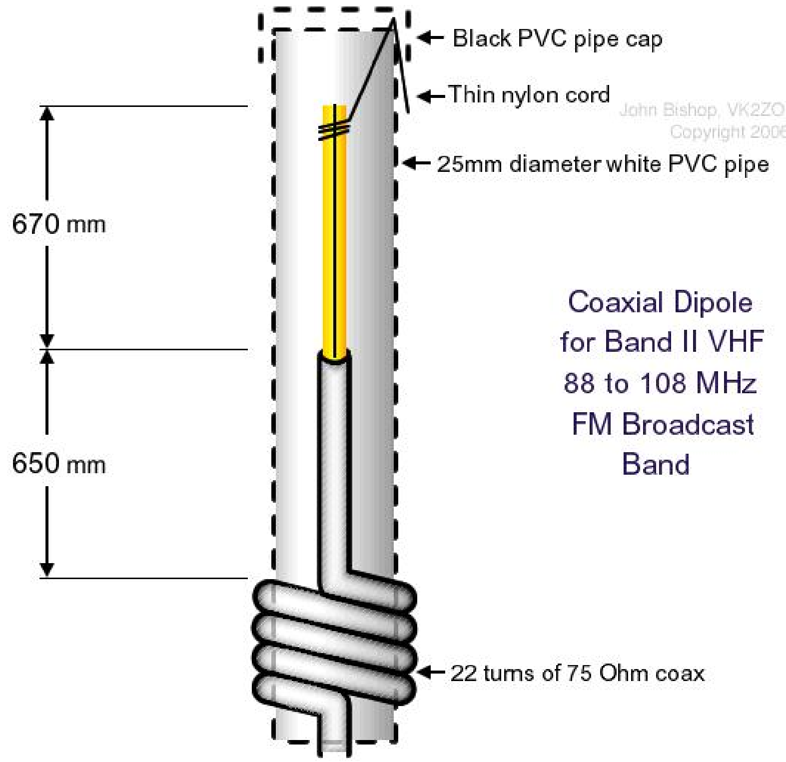
The radiating element is made from good quality 75 Ohm coaxial cable. Since VHF/FM broadcast tuners are designed to be fed with 75 Ohm coaxial cable, use high quality, low loss double shielded satellite grade coaxial cable for the feed between the aerial and the radio tuner. Use satellite F type connectors and joiners for lowest loss.

The top half of the radiating section is 670mm of the centre conductor (or a length of multi-strand PVC covered wire). The bottom half of the dipole is 650mm of the complete coaxial cable - choked off at the bottom by the coil section. The top part is held in place by a a short length of thin nylon cord, trapped in place by the top PVC cap. The cap itself is sealed on the outside by some self amalgamating tape.

The choke coil is 22 turns of the 75 Ohm coax wound around the 25mm pipe. Tightly spacing the windings of the coil will minimize the bandwidth covered but provide the lowest SWR at the centre point. A looser winding of the coil will widen the bandwidth covered, but lowest SWR achived will be a little higher.

Once the tuning of the radiating elements, coil winding and band coverage has been checked with an Antenna Analyzer, the coil section should be covered with heat shrink, taking great care not to overheat and deform the plastic pipe.

The actual final dimensions (as shown below) may well need some adjustment in length due to differences in cable and type of pipe used. However, with the dimensions shown, I achieved a minimum SWR of 1.3 at 97.4 MHz. The band edges at 88MHz and 108MHz were at an SWR of around 3.8 to 4.0 - which is probably OK for broadcast band reception. The frequency of lowest SWR can can be changed, if desired, by changing the lengths of the radiating sections - slightly longer for a lower frequency and slightly shorter for a higher frequency.



Coaxial Dipole for the 88 to 108 MHz Band II Broadcast Band
An effective, cheap and simple vertical antenna that is fed at its base

RSGB RadCom Articles:

The Controlled Feeder Radiation Dipole. Peter Dodd. RadCom, September 2012, page 22.

More On The CFR Dipole and Coax Chokes. Peter Dodd. RadCom, October 2012, page 54.

VHF CFR Dipoles and More on Common Modes Chokes. Peter Dodd. RadCom, January 2013, page 24.

The HAK Chokes Coaxial Dipole. Encouraging results from 2m to 20m. Peter Grant. RadCom, April 2013, page 22.

Join the RSGB to receive your monthly RadCom magazine: http://rsgb.org/main/publications-archives/radcom/

VK3TWO / VK6TWO Comments:

Many years ago when I was working for a Service Centre, by accident we broke a commercial white stick antenna whilst using it for a task it wasn't intended for. I found that inside the fairly expensive commercial antenna the basis for the design was very similar to the coaxial dipole (as I call them).

Our local repeater club calls them "pogo sticks", which I can only assume is due to the coax coil resembling the spring of a pogo stick. This design had RG213 being fed inside an aluminium tube (the bottom radiator), and the outer braid was then terminated to this. The inner of the coax, then terminated to an identical aluminium tube which was of course the top radiator. Where this design largely differs, is that there was also a 1/4 wave stub of coax running parrallel with the bottom radiator (note that this was for single band operation, not dual band). The whole lot then slid inside the typical white tapered fibreglass housing. I didn't cut open the bottom mounting section to see how it was choking the RF, but I assume it had a handful of ferrites inside the metal base (an alternative way of making the RF choke).

The repeater group has built probably hundreds of these and sells them for $40 at local hamfests. We had a 'Jig' made so that all of the measurements were 'pre-marked' etc, and allowed us to mass manufacture them. Last year, we had planned the typical 'working bee' to make about 30 of them, but this time we had a very expensive Anritsu Sitemaster at our disposal. We discovered that the whilst the design we'd used for decades had a good SWR, it actually was far from optimal. With a heap of 'trial and error' (and with excellent visibility of what was really going on via the Anritsu - not just SWR) we were able to fine tune the design.

From memory, we actually needed more turns of the coax than we had been using (10.5 turns from memory), and our cutting measurements altered slightly. As to be expected, the number of turns was largely dependent on the size of the conduit being used, even changing from 25mm to 30mm etc.

We took several screenshots of the final SWR plots etc. These showed that the bandwidth of this antenna as VERY wide from an SWR point of view. I'll see if I can dig some of them up for you if you'd like.

73, Heath, VK3TWO / VK6TWO
MEngSc, GDipCompSc, DipEE
www.spooktech.net

http://www.warg.org.au - The West Australian Repeater Group Inc (WARG) is the largest amateur radio club in Western Australia (VK6).

D.I.Y. J-Pole Antennas - A really simple, quick and very cheap 'home brew' project J-Pole Antennas

J-Pole antennas for 2 meters, 4 metres, 6 metres and 10 metres :

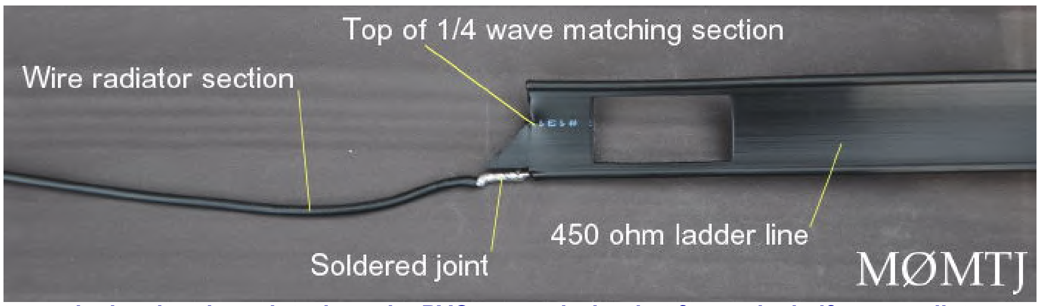
While experimenting with antennas in the garden in the summer of 2012 I thought that it would be good to have a hand-held radio in the shed to do some monitoring and make a few contacts. To improve upon the performance of the 'rubber duck' antenna I quickly made a J-Pole antenna for the 2 metre band.

It is made from a 47cm length of 450 ohm Wireman ladder line as the 1/4 wave matching section, plus a 97cm length of stranded wire as the 1/2 wave radiator. It is fed with 3 metres of Mil spec RG58 c/u coaxial cable that is soldered to the 1/4 wave matching section's impedance matching point at 3.5 cm from the bottom. The coax feeder is wound around some PVC tube to form a choke. The completed antenna is taped to a 2.2 metre long fibreglass fishing pole that I purchased from Poundland (for £1.00). It took about 20 minutes to make followed by some testing and adjustment with the antenna analyser. The fishing pole is lashed to the shed with some cable ties.

This simple antenna works pretty well, but being so low down signal strengths are not huge, but it's pleasing to get on the air with something so simple and cheap!

The Shed Antenna - a 2m J-Pole by M0MTJ
Note the simple choke balun at its base made by winding 8 turns
of the coaxial cable around a small off cut of white PVC water pipe.

The feed point of a J-Pole antenna made from Wireman 450 ohm ladder line.
For the 145 MHz antenna this feed point is 3.5 cm from the bottom of the ladder line section which is on the right hand side in this photograph. The coaxial cable used in this case was Mil spec RG58 c/u. But any good quality, low loss 50 ohm coaxial cable could be used. The wire radiator section is connected to the same conductor of the ladder line as the coaxial cable's centre conductor. For my antenna, fixed to a fibreglass fishing pole, the radiator wire was 97cm in length.



Photograph showing the point where the PVC covered wire that forms the half wave radiator section is soldered onto the top of the 450 ohm ladder line that forms the quarter wave matching section.

Inspired by DK7ZB. The J-Pole is a very effective antenna and being made of wire it is very light weight making it quite easy to fix in different positions. If you have problems installing a permanent antenna then making a wire antenna that can be easily supported on a lightweight push up telescopic fishing pole can make an ideal alternative.

The formulas to make a J-Pole antenna from 450 Ohm Wireman ladder line in this way are:

Length of 1/4 wave impedance matching section (450 ohm ladder line) Wavelength x 0.223
Length of 1/2 wave radiator (any reasonably strong PVC covered stranded wire) Wavelength x 0.471
The point at which the coax is connected to the 450 ohm ladder line will be about 5 to 10% of the length of the ladder line section up from the bottom.

The wavelength at mid point of the 2 metre band (145.00 MHz) is found by the quick calculation 300 ÷ 145 = 2.068 metres

So, to make a practical antenna:

The 1/4 wave section of 450 ladder line will be 2.07 x 0.223 = 0.47 metres long
The 1/2 wave wire radiator will be worked out as 2.07 x .471 = 0.975 metres long
The connecting point of the coax will be about 3.5 cm from the bottom of the 1/4 wave section. The optimal point may have to be found by some experimentation - as will the best length for the wire radiator.

The length of the wire radiator will be affected by surroundings. For example I fixed the wire to a fishing pole. The proximity of the fishing pole has the effect of electrically lengthening the wire; so using a 97.5cm length of wire fixed to a pole I found that it resonated (as expected) at a lower frequency, it therefore had to be shortened until the point of resonance (indicated by lowest SWR) was around 145.00 MHz. This should be done in the antenna's expected final position since the J-Pole is quite sensitive to its surroundings, so if these checks are done near the ground, once it is raised into its final position the SWR will have changed and the adjustments will have to be done again.

I found that 3.5 cm was good for the 2 metre band antenna, but for the 10 metre band version of the antenna a little more experimentation was required:

The VSWR reading may not be especially low, even though the point of resonance for the wire radiator may have been found. For the 10 metre band antenna at this this stage was about 1.7 indicating that the connection point of the coaxial cable to the 450 ladder line needs to be adjusted. The ladder line is used as an impedance transformer, transforming the very high impedance (hundreds of ohms) of the half wave wire radiator down to the 50 ohms required by the transceiver and the coaxial feeder cable. This connection point therefore affects the impedance of the antenna, the higher up the matching section it is the higher the impedance will be, and visa versa.

Once the length of the wire radiator has been set, the connection point can be moved up and down the ladder line until lowest SWR is achieved. A few centimetres of the PVC insulation has to be carefully scraped away from the copper conductor on each side of the ladder line using a craft knife. The inner conductor of the coaxial cable is quickly tack soldered on the side that is connected to the 1/2 wave wire radiator. The coaxial cable's braid is quickly tack soldered to the opposite side of the ladder line at this point, ensuring that both points are equal distance from the bottom. At this point temporary croc clips could be used, but I preferred a quick solder joint.

With radiator trimmed for resonance, the connection point of the coaxial cable can then be moved up or down the ladder line little by little; un-soldering and re-soldering the coax to the ladder line until a lowest possible SWR is achieved, indicating that the antenna is near the ideal 50 ohm impedance.

Once the ideal point is found the coaxial cable can be properly and permanently soldered to the ladder line.

6 Metre Band J Pole on the antenna analyser - it's getting close!

Each J-Pole took about 20 minutes to physically make out of the wire components. However the testing and adjusting took a bit more time. I used an antenna analyser which saved having to key the mike every time when using a basic VSWR bridge and causing unnecessary QRM, but even so, hoisting the fishing pole up and down numerous times took a little more time:

10 Meter J-Pole. For the 10 metre band J-Pole antenna this took perhaps another 20 or 30 minutes until I was satisfied with the adjustments. It may take a little longer if using an SWR meter.

6 Meter J-Pole. For the 6 metre band antenna the radiator wire had to be trimmed a little and the feed point adjusted to 6 cm, taking about 10 additional minutes to complete.

4 Metre J-Pole. For the 4 metre band, centred on 70.37 MHz

2 Meter J-Pole. For the 2 metre band antenna the wire radiator took a couple of attempts to get it to the correct length when attached to a fishing pole, but the feed point was spot on first time at 3.0 cm, again taking about 10 additional minutes to complete.

Here are some suggested dimensions for the 2 metre, 6 metre and 10 metre band versions, when supported by a fibreglass fishing pole:

Wire J-Pole Antennas	1/2 Wave Radiator	1/4 Wave Section	Feed Point
2 Metre Band Antenna	0.975 m	0.47 m	3.0 cm

4 Metre Band Antenna	1.90 m	0.95 m	6.1 cm
6 Metre Band Antenna	2.815 m	1.33 m	6 cm
10 Metre Band Antenna	4.96 m	2.45 m	15 cm

N.B. The 1/2 wave wire radiator section will be shorter than calculated when fixed to a fibreglass pole or other object.

To re-cap, the 1/2 wave section should be adjusted for resonance and the feed point position adjusted for minimum VSWR.

Sealing and waterproofing. Once the antenna is complete and has been checked and tested all the bare joints should be sealed against the weather with liquid electrical tape and self amalgamating tape. The coax should also be secured against the ladder line with a nylon cable tie as a strain relief to prevent the soldered feed point joints from breaking.

These J-Pole Antennas were inspired by DK7ZB - http://www.qsl.net/dk7zb/J_Pole/wiremanjpole.htm

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M0MTJ

Amateur Radio; Ham Radio; Radio; Transceivers; HF; VHF; UHF; Data Modes; Morse Code; RTTY; PSK31; SSTV; FSTV; Amtor; Sitor Antennas; Aerials; Cable; Coaxial Cable; Twin Lead; Masts; Poles; Propagation; Computer; PC; USB Computer Interface; Microphone Loudspeaker; Filters; Noise Reduction; DSP; Digital Signal Processing; Morse Key; SWR ; Inverted L; Inverted V; Dipole; Doublet.

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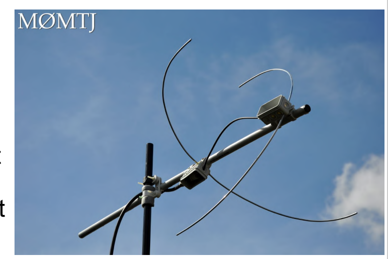
"Everything should be made as simple as possible, but not simpler." - *Albert Einstein*

MØMTJ - Experimental (Almost) Omni-Directional - Circularly (Mixed) Polarized Antenna for 144 MHz / VHF / 2 Meters.

Introduction and Background



This is an experimental project that may lead to further development in the future, but even as presented below, it does work and may prove very useful.

I have therefore included this page of information so that you may can construct the aerial and develop these ideas further - either just out of interest and for the sake good old traditional Amateur Radio experimentation or for more permanent and practical uses!

The idea was sparked by the fact that I had been toying with the idea of removing the rotator and dual-band horizontal Yagi from my lightweight push-up aluminium mast to reduce mass and visual impact. I certainly did not want to lose access to the horizontally polarized portions of the 2 Metre (144 MHz) or 70cms (432 MHz) bands, so decided upon trying an Omni-Directional, horizontally polarized aerial.

The question was which antenna would I use to replace the rotatable dual-band Yagi?

Due to the weight of the rotator, the lightweight aluminium mast could not safely be pushed up higher than about 6 meters. Therefore, the Yagi on the stub mast was never much higher than 6 or 7 metres above the ground. A lighter weight omnidirectional aerial, without the heavy rotator, would allow the past to be pushed up to, perhaps, 8 or 9 meters. Maybe even to its full 10 meters on a fine day!

My thinking is that this additional height may compensate slightly for the loss of gain from the Yagi. The additional height would also benefit my vertical Coaxial Dipole for 6 Meters (50 MHz) which sits at the top of this mast. A small bonus.

I decided that I would try simple Halo antennas (HAlf wave LOop) and Big Wheel antennas for 2 Meters and 70cms.

Circularly Polarized, Omnidirectional Antenna for VHF 2 Meters / 144 MHz

.
However, before embarking on those particular experiments and possible future changes, I wanted to experiment with mixed polarization, or more correctly in this case, Circular Polarization - the subject of this project and article.

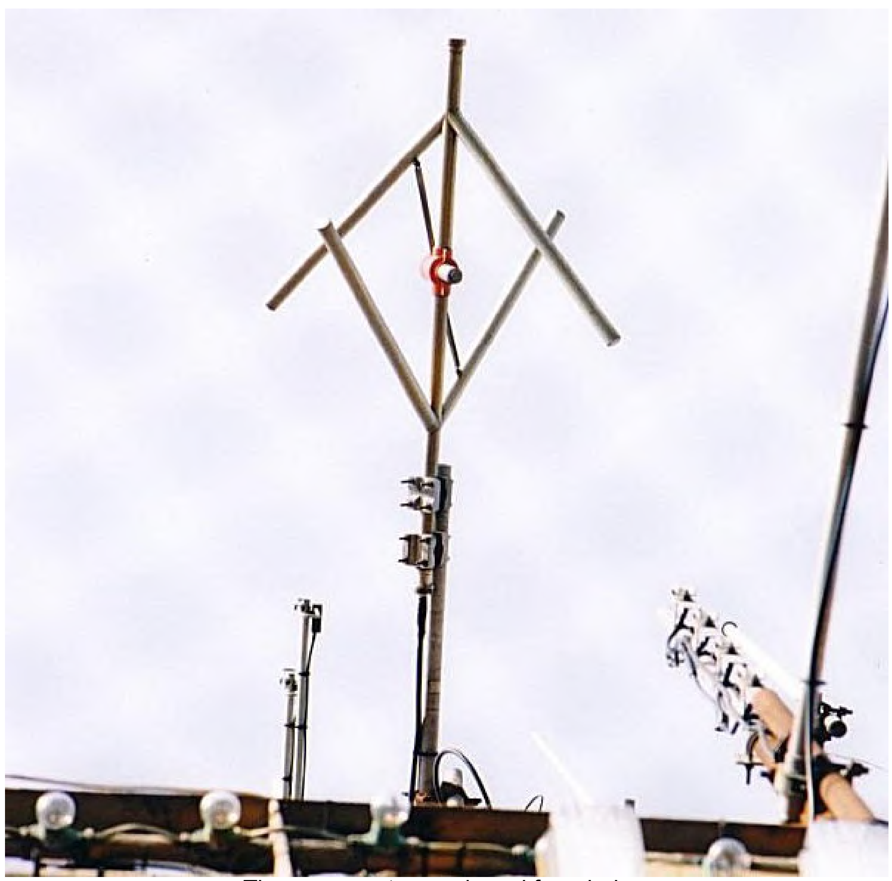
Why? - Well, when the IBA (Independent Broadcasting Authority) began building transmitters for their Independent Local Radio (ILR) in 1973, they specified that mixed polarized aerials should be used used at each of their VHF/FM

transmitter sites, starting with Croydon for LBC and Capital Radio in London, then Black Hill for Radio Clyde in Glasgow and Lichfield for BRMB in Birmingham and the many other sites that followed. The aerial systems were either described as "Mixed", "Slant" or "Circular".

The reason that mixed polarization was chosen was to improve reception on car radios and portable radios that generally used a vertical or slanted telescopic rod aerial. The BBC, at the time, used horizontal polarization for VHF/FM radio which was good for permanently installed roof-top receiving aerials, but provided poorer reception for listeners with portable sets and car radios. Some years later the BBC followed the IBA and began converting that majority of their transmitter sites to mixed polarization to improve reception and reduce mobile 'flutter' effects.

I thought that I would like to experiment with mixed polarisation and took some inspiration from some of the more recent, and simpler, antennas that have been installed at commercial radio ("ILR") transmitter sites. Two examples are shown below, both from the Radio Wave transmitter site at Blackpool Tower. The original aerial and its more recent replacement.

Original SBS transmitting aerial for
Radio Wave Blackpool 96.5 MHz
Photo from MB21.co.uk



The newer antenna viewed from below
Photo from MB21.co.uk

What's Needed

4 x 500mm lengths of 4mm diameter aluminium rod
2 x Dipole Centres

6 x Solder Tags with 3mm diameter hole
2 x Dipole Mounting Boxes - e.g. IP54 85 x 45 x 40mm
2 x Stainless Steel Nuts, Bolts and Washers M4 x 20mm
2 x Stainless Steel Nuts, Bolts and Washers M4 x 14mm
4 x Stainless Steel Self Tapping Screws No. 4 (2.9mm) diameter by 9.5mm long
1 meter of 20mm or 25mm Diameter PVC Pipe
8 x Pipe Clamps to suit diameter of boom and diameter of supporting mast
4 x Stainless Steel Nuts, Bolts and Washers
2 x End Caps to suit diameter of PVC boom (i.e. either 20mm or 25mm)
1 x SO239 Chassis Mount Socket
500mm length of small diameter coaxial cable, e.g. RG188 A / U - 50 Ohms PTFE coaxial cable
1 x piece of PVC tube for choke balun - 16mm diameter x 30mm long
1 x length of coaxial cable for phasing section
Some small self tapping screws to fix the pipe clamps to the boom

These items will be available from many and various sources, but Nuxcom is a good supplier - http://shop.nuxcom.de/

The antennas essentially comprise of two Crossed Dipoles, set a 90 degrees from each other. In the first photo, the antenna can be seen to have one dipole positioned vertically and the other horizontally. The second photograph shows that the to dipoles are again set at right angles, but one slopes 45 / 225 degrees and the other at 315 / 135 degrees.

The two dipoles are connected to each other, but have to be fed with the current to each dipole 90 degrees out of phase. This is called phase quadrature. It is a very common method used for other types of antenna, such as the Turnstile which is often used for communication with satellites where circular polarization must be used.

One dipole is connected directly to the coaxial cable. (I used Westflex 103 coaxial cable, for lowest loss, to feed the antenna). The second dipole has to be fed via a 1/4 wave (90 degrees) matching section. I had an off-cut of RG58, so used this for my initial experiment.

A quarter wave at 145.00 MHz is 300 / 145 = 2.068m / 4 = 51.7 cm. However the Velocity Factor (VF) of the cable has to be taken into account because radio waves travel more slowly through transmission lines than the do through free space.

Ideally I should have measured the VF with my antenna analyzer, however I took the typical VF of RG58 as being 0.66. So 51.7cm x 0.66 = 34.1cm. I cut the cable to 34.1 cm and used this to connect the two dipoles together.

Initially I cut the 4mm diameter aluminium rod into four 50cm long pieces and mounted them into the two dipole mounting boxes using the Nuxcom Dipole Centres. A small hole has to be very carefully drilled into the end of each rod to align with the fixing hole of the dipole centre. Then very carefully screw the 2.9mm stainless steel self tapping screws into each hole being sure not break off the head of the screws. When tapping these holes it is best to ease back and forth until the hole is successfully tapped.

The dipole centres and pipe clamps are fixed to the box with the 20mm diameter M4 hex bolts, washers and nuts.

The second pipe clamp is fixed to the box with the 14mm long M4 stainless steel hex bolt, washer and nut.

Each mounting box is fixed to the boom by clipping on the pipe clamp. The two dipoles are mounted at right angles (90 degrees) to each other, approximately 335mm apart. Once the final adjustments have been made and the positions along the boom are decided, the clamps are held firmly in place by screwing them to the boom, as can be seen in the photographs below.

Each dipole is then carefully bent into a semi-circle.

The SO239 socket is then fitted to the box and the choke balun is wound and one end of the coaxial cable soldered to the socket and the other end fitted with the solder tags. The small 2.9mm x 9.5mm stainless steel self tapping screws are then used to fix the tags to the dipole centre.

Now connect this dipole to an antenna analyzer (or SWR meter) and check the point of resonance. I decided to centre the aerial on 144.3 MHz. Almost certainly the dipole will be too long. I had to cut off 1mm of rod from each end.

Once complete, do the same for the other dipole so that they are exactly the same size.

Next, the phasing cable is prepared, as mentioned above. A suitable diameter hole is drilled in the end of the box opposite the SO239 socket and the phasing cable passed through this and soldered on to the two tags, as can be seen in the photograph below.

A similar small hole is then drilled into the other dipole mounting box and the other end of the phasing coaxial cable is passed through this, two solder tags are soldered on to the end and then fixed into place on the dipole centre using the small self tapping screws.

Now connect the antenna analyzer again, using a few metres of low loss coaxial cable, and mount the antenna in some free space, preferably outside on a pole about two or three metres above the ground a. It will almost certainly be found that the point of resonance is now two low, so each dipole will now need to be carefully trimmed, cutting small and equal amounts off each of the four ends until the point of resonance is around 144.3 MHz.

It should be possible to obtain an SWR of 1.5:1 or less across the 2 Meter band - to achieve this it may be necessary to move one of the dipole mounting boxes further away, or closer together to the other. Also, it may be necessary to bend the dipole rod of each dipole element inwards, or outwards slightly. I was able to achieve an SWR of 1:1 with an impedance of 50 Ohms according to the antenna analyzer.

Once the adjustment were complete, I used 20 meters of Westflex 103 to connect the antenna to the Icom IC-706 mk2g. A similar length of the same cable is used to connect the 5 element horizontal Yagi to the radio. A low loss coaxial switch was used to make instand comparisons between each antenna.

I raised the experimental antenna to 8 meters above ground level on the telescopic pole and began to make some comparisons.

My guess was that the experimental omni-directional circular polarized antenna would be noticeably inferior to the much higher gain, horizontal, directional Yagi.

The Yagi has a quoted gain of 8.4dDBd (i.e. gain with reference to a standard dipole - not dBi).

A standard straight dipole has a gain of 0 dBd. However if it used horizontally and is bent into a circle to produce a roughly omni-directional radiation pattern, then the gain must be reduced, so I assumed that the 'gain' must now be negative, perhaps -1 or -2 dBd.

Additionally, being as this is a circularly (mixed) polarised antenna, the power is essentially divided in half across the horizontal plane and the vertical plane. i.e. another 'loss' of 3dBd.

Therefore the gain of the antenna may be assumed to be -5dBd (minus 5 dBd), i.e. about 1 S point down on a simple straight linearly polarized aerial and about 13 dBd down compared to the Yagi - i.e. about 2 or 3 S points worse.

Here, at my QTH in Staffordshire, the Kent beacon on 144.430MHz on my 5 element Yagi is just audible, although there is no S Meter reading. I therefore did not expect to be able to hear it on the experimental antenna as it is so weak, but to my surprise, the beacon was still there - obviously a bit weaker, but still audible. That was an encouraging start!

I therefore went ahead and made some QSO's with other stations who were using both vertical and horizontal polarization and also made some comparisons purely on receive.

I therefore went ahead and made some QSO's with other stations who were using both vertical and horizontal polarization and also made some comparisons purely on receive.

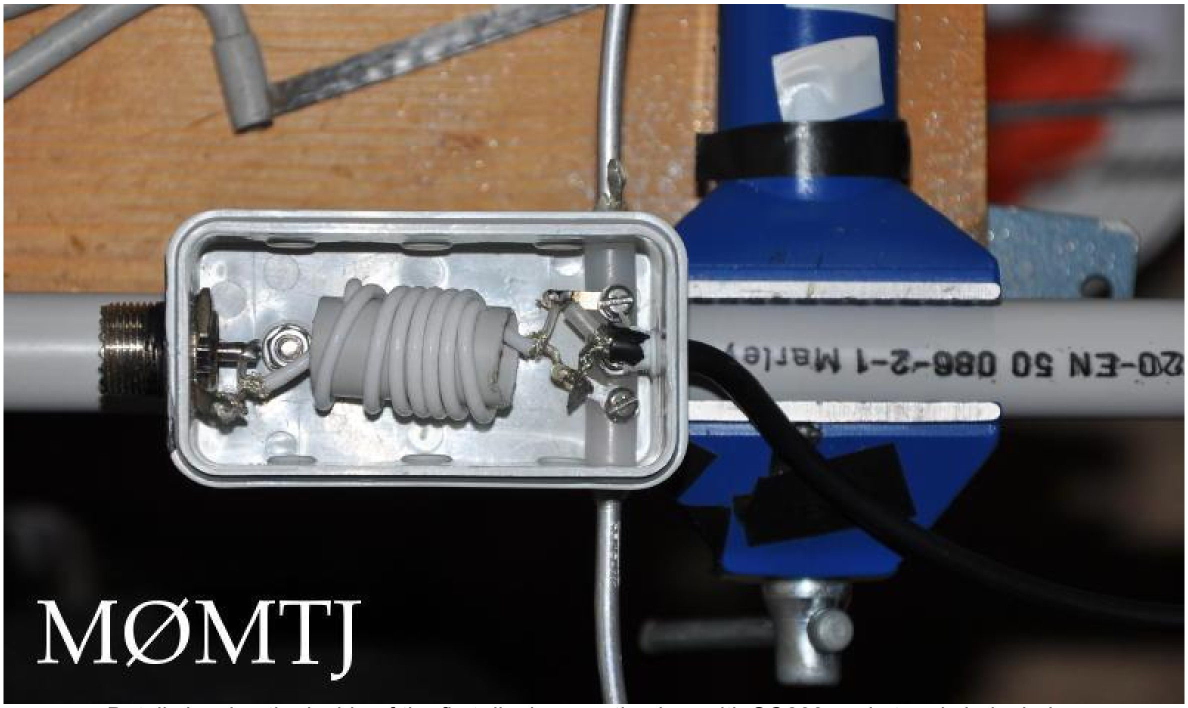
I haven't recorded enough data to draw truly meaningful conclusions. It's not scientific either. However, my impression from what I have recorded and from other general use is that the performance is broadly in line with my expectations - i.e. about 2 or 3 S points, or around 12dB, down on the Yagi.

Station	**Location**	**QSO or RX**	**Mode**	**Other station's Aerial**	**Rprt Sent (Yagi)**	**Rprt Rec'd (Yagi)**	**Rprt Sent (Omni)**	**Rprt Rec'd (Omni)**
G3XEV	Sedgley	QSO	SSB	V2000 Vertical	S2-3	S7	S6-7	S7
2W0JYN	Rhos	QSO	SSB	3 Ele Horiz Yagi	S6	S9	S5	S7
2W0JYN	Rhos	QSO	SSB	Vertical Colinear	S1	S1	S0	S0
G8WEG	SW B'Ham	RX	FM	Unknown (Vert?)	N/A	N/A	S9+20	N/A
MW0WML/p	GWNW012	QSO	FM	Vertical Dipole	N/A	N/A	S9+10	S8
G7HEM	Stourbridge	QSO	SSB	6 Ele Horiz Yagi	S7	S9	S2	S3
N/K	Burton	RX	SSB	Unknown (Horiz?)	S9	N/A	S5	N/A

With particular thanks for John G3XEV and Steven 2W0JYN for their assistance with these initial tests!

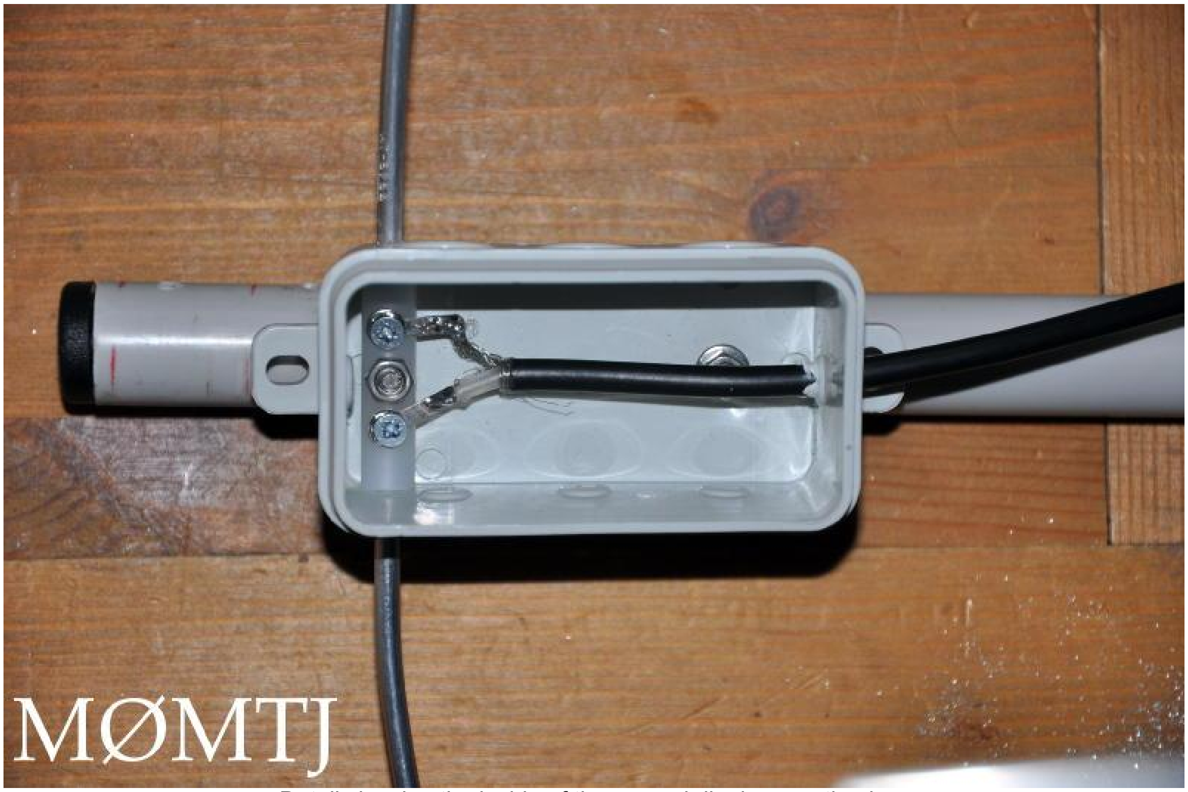
I hope this information is useful and may encourage you to experiment further and make some much better scientific comparisons!

If you have any comments, please do email them to me via the contact page here.



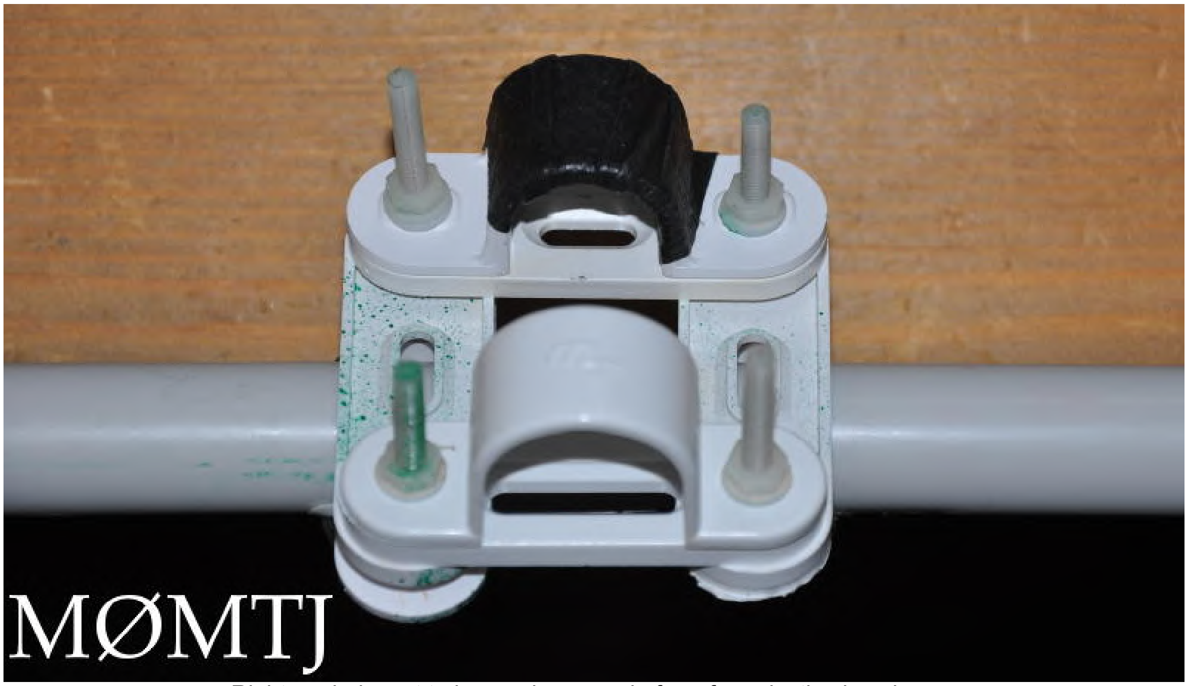
Detail showing the inside of the first dipole mounting box with SO239 socket and choke balun

Nuxcom Dipole Centre for 4 mm dipole rods
10 mm space between dipole rods
Three holes: One in the middle for fixing the box on the boom. The other two for connecting the cable to the dipole rods.
Length: 36 mm
Space in the between rods: 10 mm
Outer diameter: 8.4 mm
Inner diameter: 4,1 mm
Material: Polyamid
http://shop.nuxcom.de/

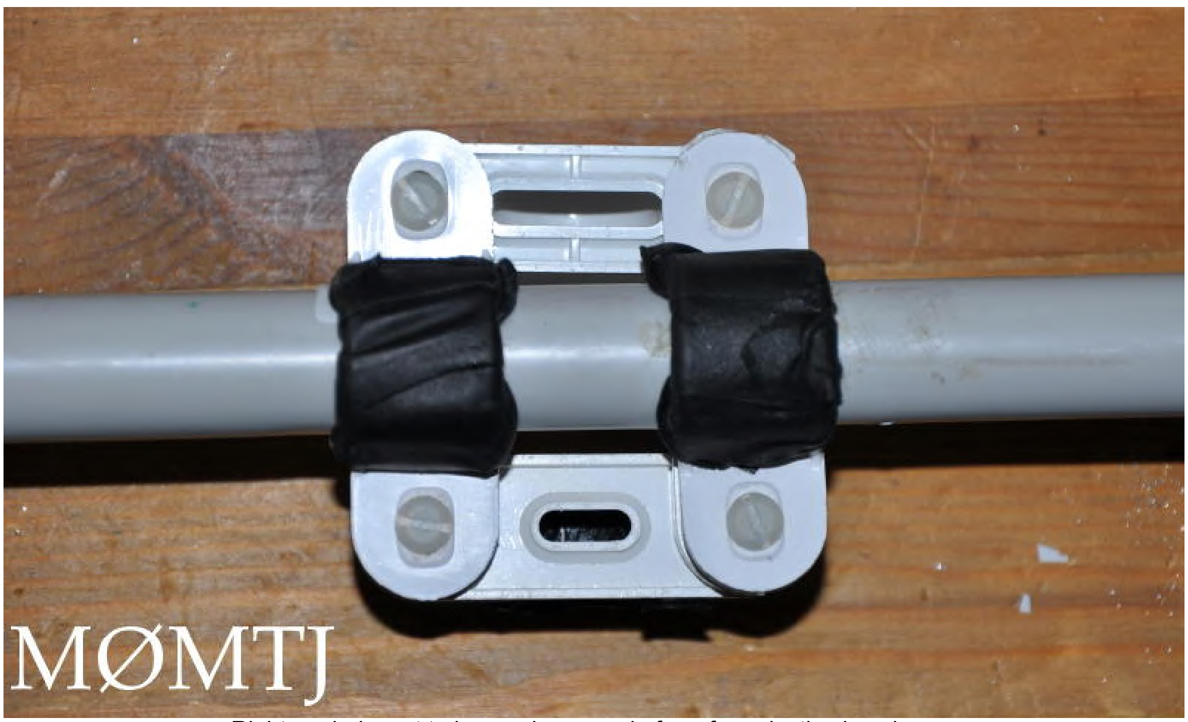


Detail showing the inside of the second dipole mounting box

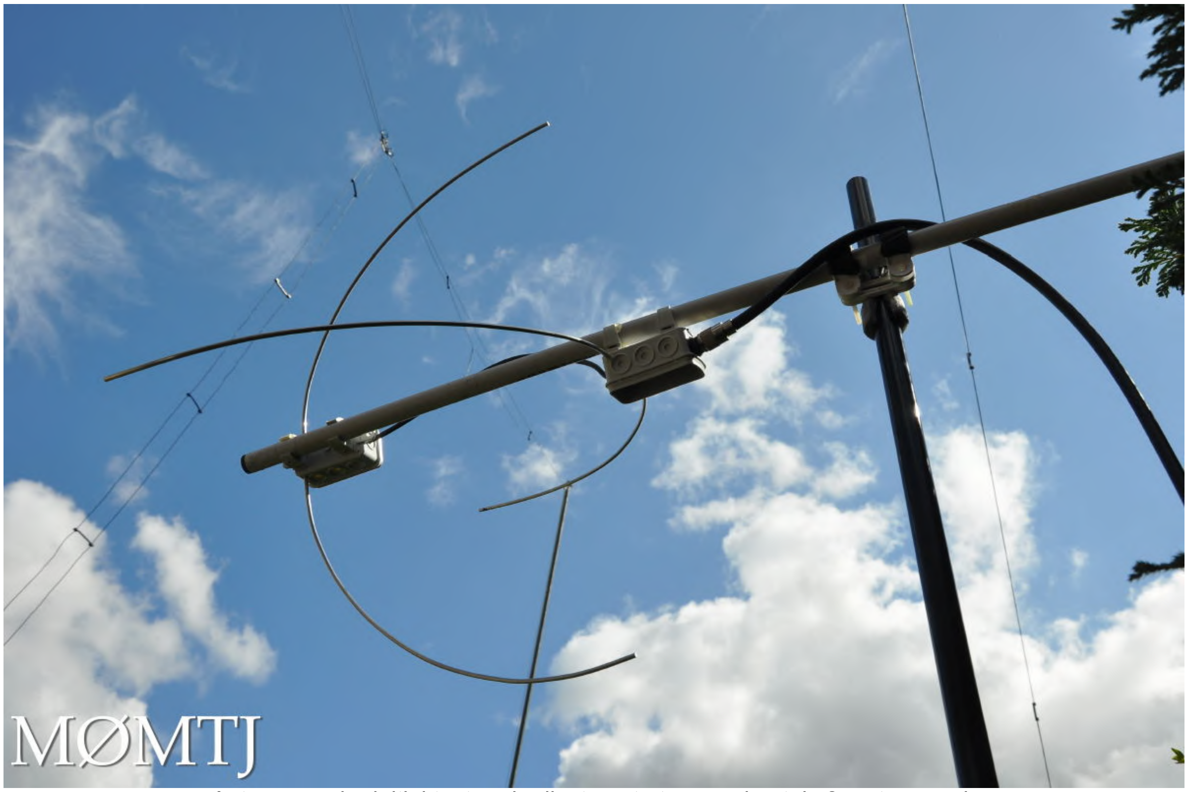
Detail showing how the dipole mounting box is fixed to the plastic pipe with pipe clamps and firmly secured in place with small self tapping screws.



Right angled mast to boom clamp made from four plastic pipe clamps

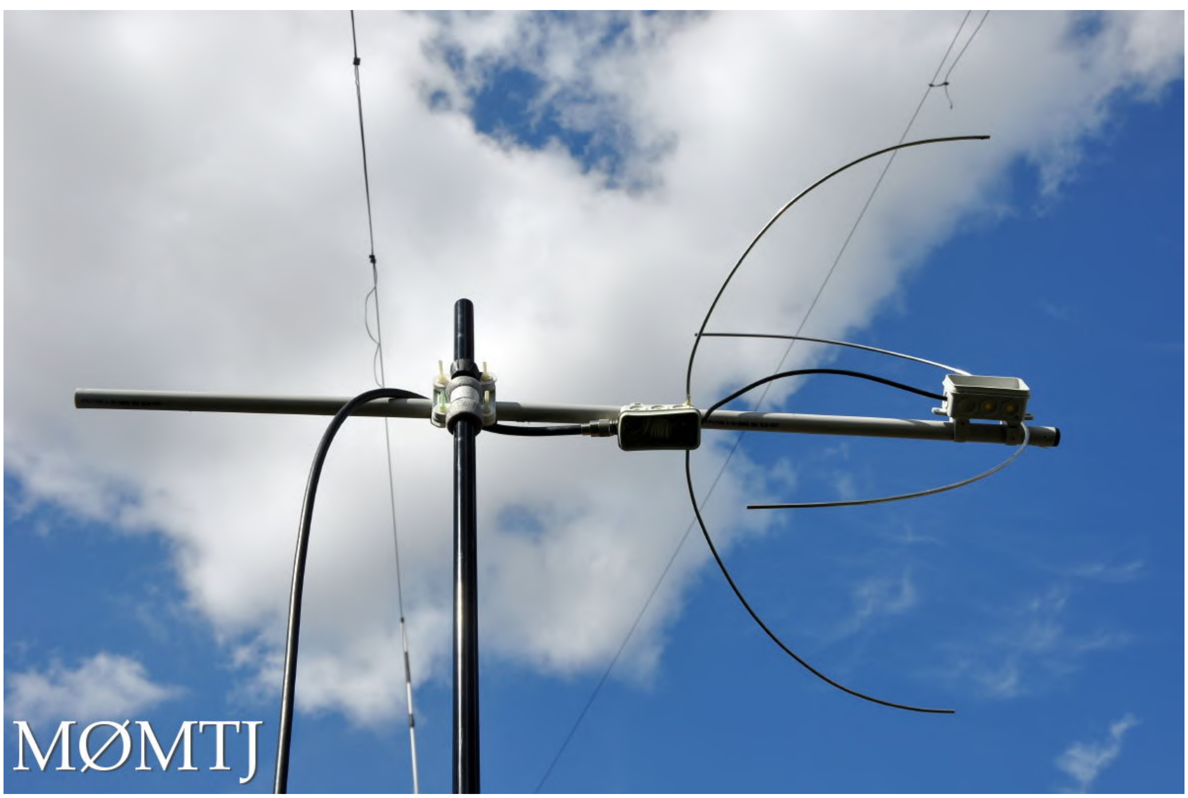


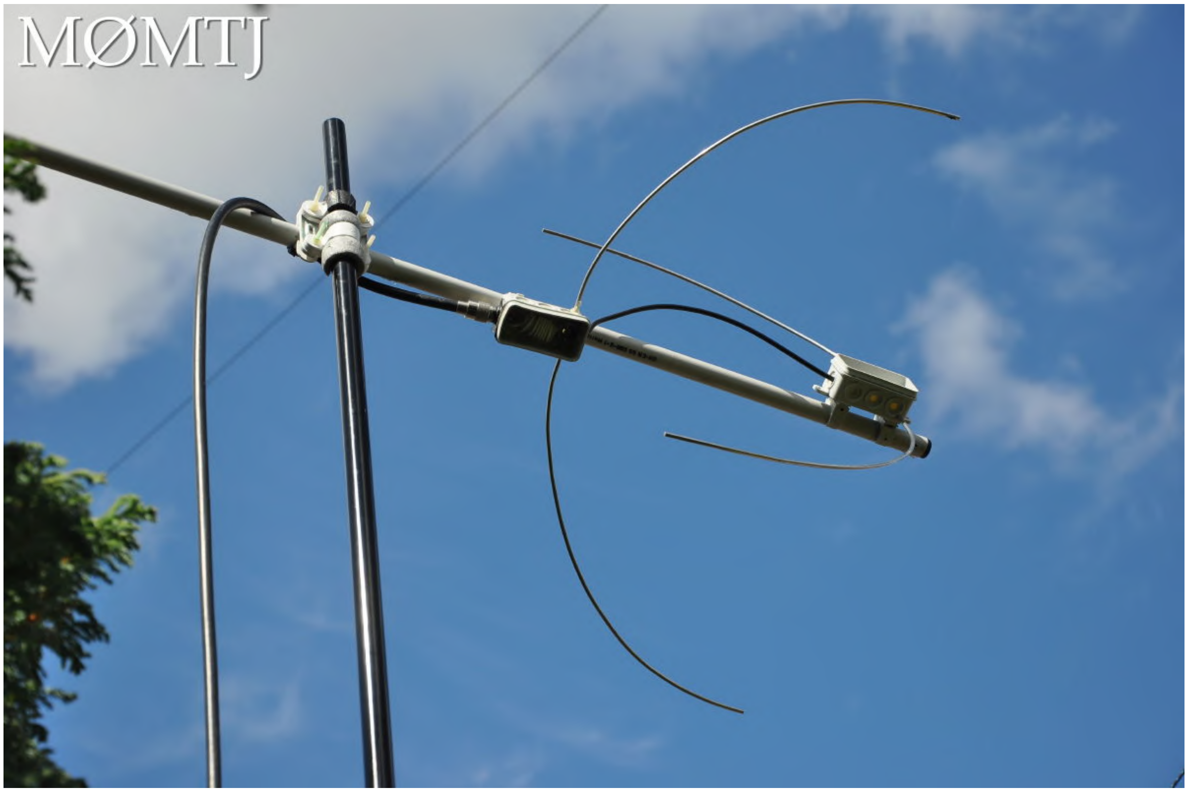
Right angled mast to boom clamp made from four plastic pipe clamps

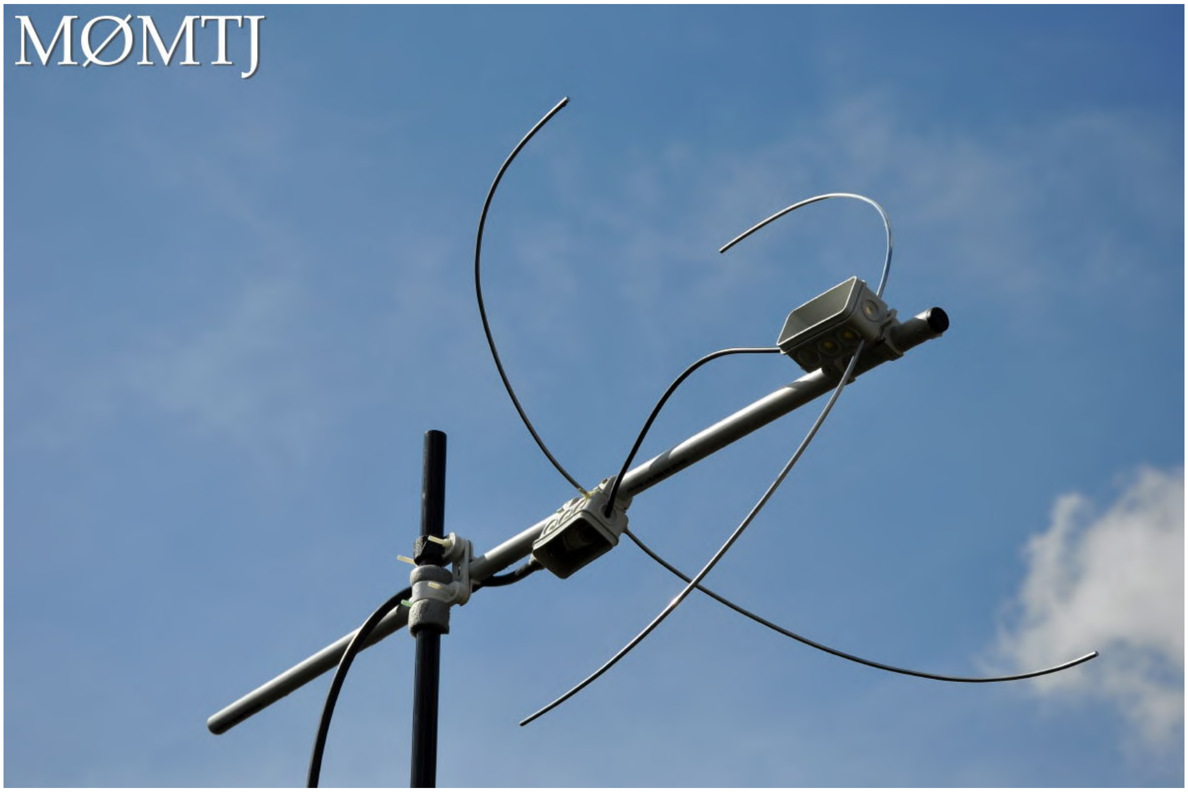


Antenna under initial test and adjustment at approximately 2 metres a.g.l.
The coaxial cable is low loss Westflex 103
(My HF Doublet antenna, fed with open wire balanced line can be seen in the background on the left)

After adjustment to element lengths and dipole positions along the boom arm, the antenna shows a good match.




MØMTJ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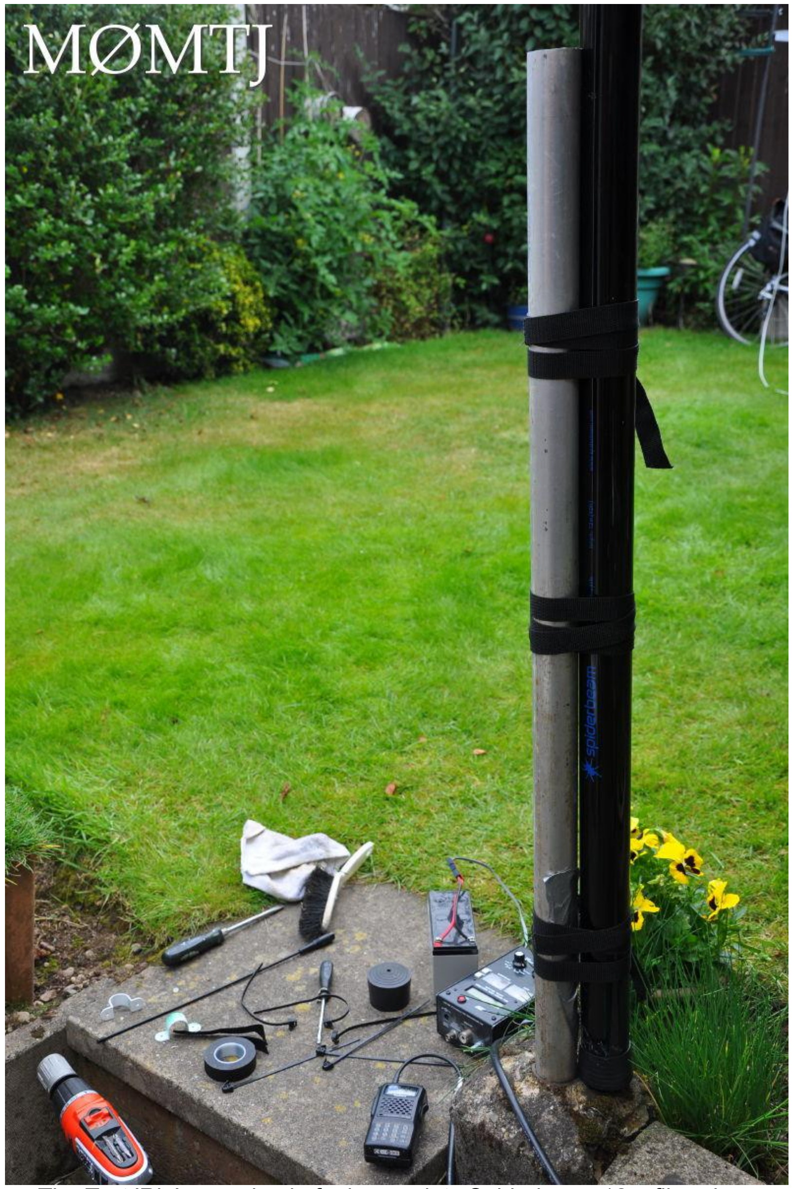

The Test 'Rig' comprised of a heavy duty Spiderbeam 12m fibreglass telescopic pole with the antenna mounted approximately 8 meters a.g.l.

If you have any comments, please do email them to me via the contact page here.

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Radio Interference?:
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British Telecom, BT Home Plug
P C World, Powerline Adapters
YouView, Belkin Linksys
Netgear Devolo, BT Vision - BPL
Radio Interference
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Amateur Radio; Ham Radio; Radio; Ground Plane Vertical; Sloper; HF Antenna; Dipole;
Doublet; Antenna - The Best Multi-Band Antenna for Easiest Construction, Quickest Deployment and Lowest Cost

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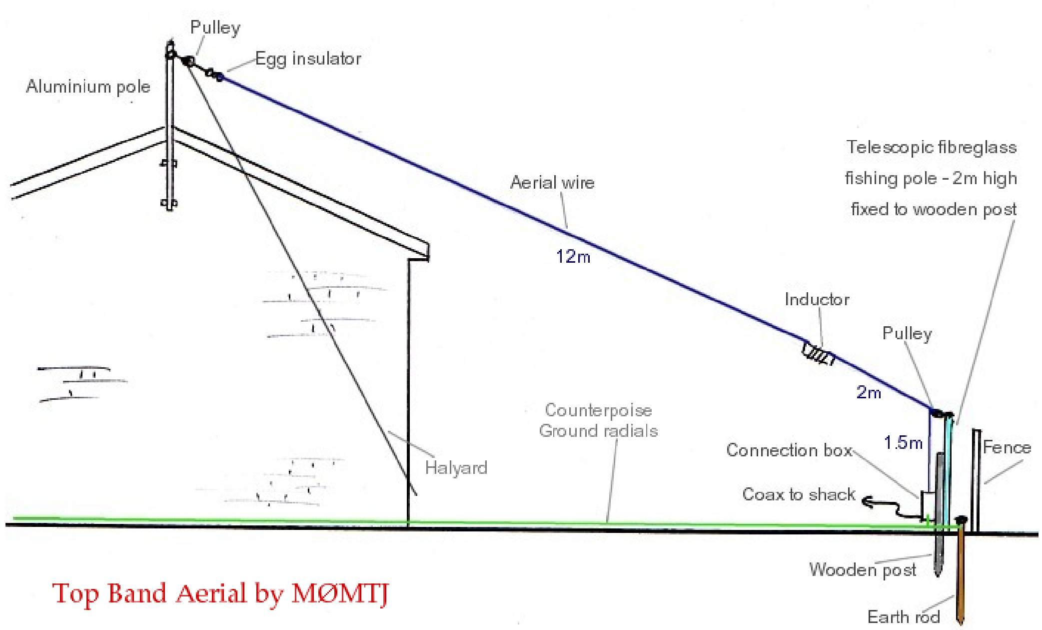
Compact Top Band Antenna - An Inverted L for stealth with low(ish) visual impact

With a small back garden there is no way that I could accommodate an aerial for the 160m band that would be anything approaching full size. A full size dipole would be about 65 metres long and would need to be mounted at a very good height to be at its most effective. A full size vertical 1/4 wave would be about 37.5 meters tall. Impossible! Bending a 1/4 wave wire into an inverted L would still result in a very long wire - say 10 metres vertically and 27.5 metres horizontally. Still too large.

Full size top band antennas are big, far too big for my small plot, so I have tried a few different shortened 160m aerials. I really would prefer to use a balanced dipole not only for the radiation efficiency, but just as importantly for the lower noise on receive - like a ground mounted vertical aerial an inverted L can be rather noisy on RX. However I have to settle for a compromise, so shown in the drawings and photographs below is my current top band aerial, along with some previous experiments and ideas further down the page.

This incarnation of my Top Band aerial takes two forms. A compact Inverted L and, in its lower position, a less conspicuous sloping wire, shown below:



General layout of Top Band Aerial with fibreglass pole retracted to a height of 2 metres
Wire lengths are approximate: Inductor 5cm dia with approx 40 turns of 0.9mm e.c.w.

G-WHIP ANTENNAS

My first experiments were with a base loaded sloper which worked ok-ish for local ground wave, but could have been better. The first weak link that I wanted to change was moving the base loading coil further up the aerial wire so that it would be positioned on the more horizontal section.

It was also very low, so could surely benefit from some additional vertical height. However I could not realistically erect another permanent pole in the garden for fear of upsetting the XYL!

Therefore I decided that I needed a design that could be semi-permanent and offer two slightly different configurations: The idea is that, as a sloping wire, the aerial can be left in place at all times for RX and still be operable on TX. Since it is essentially just a wire sloping from fence height (2m) up to the roof apex it has fairly minimal visual impact. Alternatively, when required - at night - the telescopic pole can be extended to transform the aerial into the larger Inverted L.

The Earth and Radials: The aerial is fed against ground, so the ground needs to be as good as possible. At the base of the aerial a copper earth rod is driven into the ground. Additional ground radial wires are also added to provide a counterpoise and help reduce earth loss. The more the merrier.

The Support: A 10 metre long telescopic fibreglass fishing pole is used as part of the support. A wooden post was driven into the ground, adjacent to the earth rod. The connector box is screwed on to the post and the fishing pole was fixed to the post using nylon straps.

Since the top sections of a fishing pole are too thin to support the aerial wire, the last four sections were removed, leaving the pole 6 metres in length, which is a respectable height in a small back garden, though being even taller would be better.

A small lightweight pulley is fixed to the top of the fibreglass pole using two nylon ties - as seen in the photograph. As a sloping wire, the fishing pole is collapsed to 2m in height while being extended to 6 metres when being used as the 'full' Inverted L. The pole is quite flexible and so will tend to bend quite noticeably when 6 metres long with the wire attached to the top. This could be remedied by adding a back guy rope of required.

The far end of the aerial wire is tied to a egg type insulator and nylon halyard which is suspended through a pulley on a pole attached near the apex of the roof. The nylon halyard is tied off on a cleat hook near ground level to enable easy raising and lowering of the aerial wire.

The Wire: Aerial wire is PVC covered stranded wire of about 16/18 swg http://www.whwestlake.co.uk. The wires were cut for the maximum length that could be fitted into the available space - so as much wire was in the air as possible. This was about 3.5 metres from the feed point to inductor and around 12 to 13 metres from the inductor to the far end.

(If you make one of these get the vertical portion as high as possible and the horizontal section as long as possible and reduce the coil's inductance accordingly)**.**

The Inductor and Resonance:

The resonance of the aerial system was adjusted not by altering the length of the wires, but by changing the inductance of the loading coil.

I had some 0.9mm (20 s.w.g.) enamelled copper wire on a reel, so I used that to wind the coil. The coil former is 5cm in diameter and about 15 cm long, cut from an empty tube of silicone bath sealant (the 'gun' type). Two holes are drilled in the former for the fixing bolts and wing nuts that secure the aerial and coil wires.

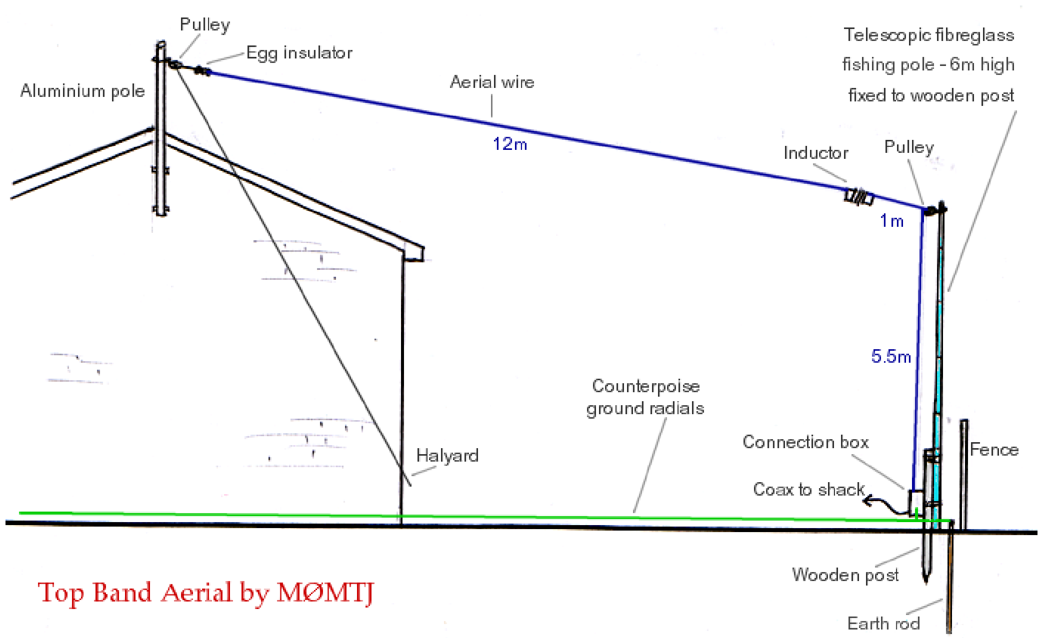
I used an MFJ antenna analyzer to check resonance and adjust the number of turns. Initially the coil was wound with 60 turns, but the resonance was well below 1800 kHz. Turns were gradually removed until resonance was around 1940 kHz, leaving 39 turns on the coil. (Thicker e.c.wire might have been better, I would have preferred to use something like 18.swg 1.2mm diameter and this may possibly get changed in the future)

Enamelled copper wire:
http://www.esr.co.uk/electronics/cable-copper.htm

When the adjustments were finished the aerial wires and coil wires are terminated with lugs and fixed in place with the bolts and wing nuts. The winding was also covered in duck tape. All exposed connections should be suitably protected against the weather for a permanent installation.

When setting up any aerial an antenna analyzer is extremely useful - allowing all the measurements to be done in the garden or back yard thereby simplifying and speeding up the process considerably. These simple

measurements can be made using the transceiver and VSWR meter, though that is obviously less convenient and will involve transmitting regular short burst of carrier, so it's very important to ensure that the power used is the absolute minimum and that the frequency being used is clear.



General layout of Top Band Aerial with a fibreglass pole extended to a height of 6 metres
Wire lengths are approximate: Inductor 5cm dia with approx 39 turns of 0.9mm e.c.w.

To transform the aerial to the Inverted L format (shown in the above diagram) I envisaged that changing the first length of wire, from a 3.5 metre length to 6.5 metre length, and the inductor would be necessary. I had assumed that a coil with less inductance (fewer turns) would be required due to the longer length of aerial wire used in the Inverted L arrangement.

I was, however, proved wrong. On first attempt I left the original coil in place, just adding the longer wire section (from connection box to coil) and raising the pole to its full 6 metres. The point of resonance was only about 20 kHz away from where it was as a sloper.

This, I think, can be explained by the fact that in the sloper configuration, the wire is close to the ground, other objects and vegetation which will in effect add loading to the aerial, Consequently a loading coil with less inductance than might otherwise be expected is required. So, by happy coincidence, the same coil is also suitable for the longer wire that is at a greater height (and therefore is influenced less by ground loading).

This, quite by chance, made the swap from Sloper to Inverted L a little easier since there was no need to wind a second coil - the change being made by merely adding the longer first wire section and pushing up the pole to its full 6 metre height.

If there are no concerns or objections to installing a tall pole at the bottom of the garden, then the Inverted L arrangement could be left as a permanent installation. In that case the pole need not be a fibreglass fishing pole, although it is still an attractive lightweight method, instead a couple of 3 metre long sections of treated timber could be joined together to form a 6 metre high post - the higher and longer the better though!

These links may be useful in helping to calculate loading coils:

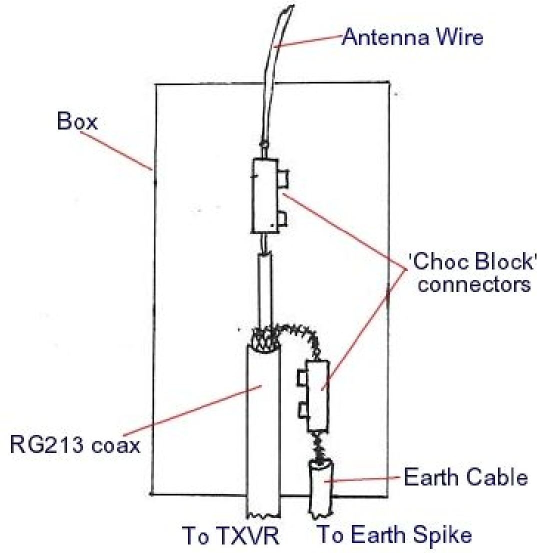
Antenna Loading Coil Calculator : http://eweb.chemeng.ed.ac.uk/jack/radio/software/loading.html

Coil winding design program : http://ecosse.org/jack/radio/software/newcoil3.html

Loaded dipole calculator by K7MEM : http://www.k7mem.com/Electronic_Notebook/antennas/shortant.html

Ring Core Calculato r: http://www.dl5swb.de/html/mini_ring_core_calculator.htm

Top Band Inverted L - photograph showing the wooden support post with telescopic pole attached with connection box, cables and earth rod. The cable entering from the left is the earthing strap which is connected to ground rods and radial wires. The coaxial feeder cable exits from the bottom right of the box and is wound around a length of white plastic pipe to form a simple RF Choke.



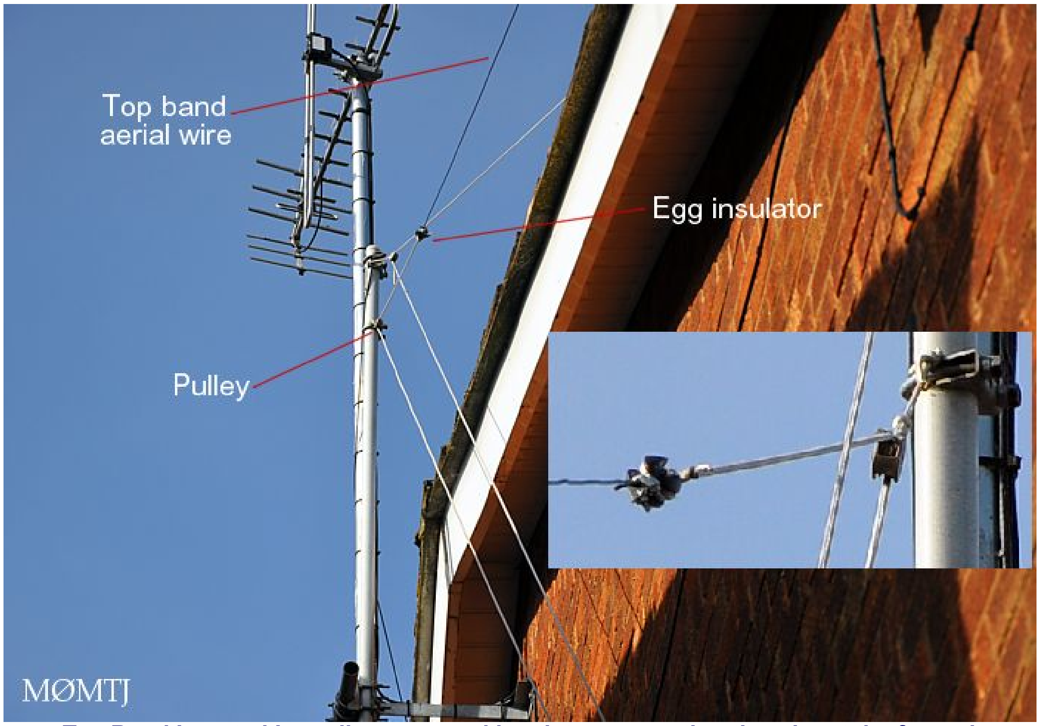
My original implementation which used 'choc block' connectors. The final design has all soldered joints with a stainless steel bolt and wing not at the top of the connecting box.

Top Band Inverted L - pulley on top of the 6m telescopic pole

Top Band Inverted L - loading inductor.

This is the unfinished coil, the connections on the left are properly finished off using lugs, but the connections on the right are unfinished to allow adjustment of the number of turns. When that is settled the final lug is soldered to the end of the enamelled copper wire and held in place with the bolt and wing nut. The coil is 39 turns of 0.9mm e.c.w., wound on a 5cm diameter former made out of an empty silicone bathroom sealant tube. (I would have preferred to use slightly thicker e.c.w. of about 18 swg 1.2mm diameter, so that may get changed in the future)

Enamelled copper wire:
http://www.sycomcomp.co.uk
http://www.esr.co.uk/electronics/cable-copper.htm



Top Band Inverted L - pulley, rope and insulator supporting the wire at the far end

Top Band Inverted L - supported by a 6m long fibrelass (roach) pole

Top Band Inverted L - looking up!

The photo exaggerates the bend a little, but it's not enough to worry about. The bend could easily be corrected by adding a back guy to pull the pole back towards the vertical position, but for this job it's fine as it is.

DOES IT WORK?

Yes! This aerial does work, I am glad to say!

It works better than my initial short sloping wire shown further down this page, which is what one would expect!

Rather than merely settling for a local ground wave signal I was very pleased to contact Top Band enthusiast Steve G7KLJ on my first attempt. Steve is 170 miles distant from me and the night time sky wave provided a pretty good result. G7KLJ gave me a 5 / 8 with my 100 watts on 1843kcs using my small aerial. I gave G7KLJ 5 / 9+10 with Steve's large doublet and 400 watts (lovely audio too Steve!).

Admittedly that's potentially a 16dB difference, which is pretty huge, but G7KLJ had the benefit of 300 more watts - that's a 6dB advantage. It also depends on how the individual S meters compare. Steve seemed to indicate that his S meter was a bit on the lazy side - 1 S Point pessimistic? But maybe my S meter similarly pessimistic?

Compared to a full size inverted L my loaded aerial is less than half the size and is obviously going to lose out, but by how much? Half the size, half the effective power - 3dB down? Probably a lot more - 6dB? There's one S point lost already (Who wants to bet that it's a lot more than that?). Since I have a ground system that is far from ideal there's another few dB's lost - another 6dB? That would be 2 S Points lost before taking into account anything else. This is all pure guesswork and speculation admittedly and probably quite groundless (almost literally in my case), and might best be described as pointless ramblings! (Where did the delete key go?) The pessimist? The realist?

The only thing proved by this single event is that my aerial radiates at least something useful - and that G7KLJ has a great station! www.g7klj.com

Droitwich

OK so it's not Droitwich, but it does work and gets me on Top Band when otherwise there would be no chance.

I am happy - but as with anything improvements can always be made. The aerial could be taller perhaps, though I cannot make it any longer. The earth system could be far far better, though I would struggle to accommodate any improvements at the present QTH. I could use better coaxial cable and also (importantly) attempt to lower the received noise by experimenting with chokes or burying the feeder to reduce common mode currents.

Plenty to think about and plenty to play with!

Important notes on effective Grounding by Jim K8OZ

Mike - I was reading about your work on the 160 meter Inverted L, and it makes me want to go out and build some more antennas! Congratulations. Your story is fascinating, and very well documented.

The only thing I can offer as a suggestion is to get as much radial wire along the edge of your property as possible (assuming your XYL will not allow you to bury radial wire all over your yard). Even if you can only run multiple wires 1/8th of a meter apart from each other, and parallel to each other, your losses will be reduced. The ground losses have quite an impact on your transmitted signal, so any wire you can "hide" along the edge of your property will help improve your signal strength - little, by little...! { It may also affect your resonant frequency slightly, but that's easy to deal with by adjusting with an antenna tuner or slightly changing the loading coil. }

Good luck OM, and keep up the refinements on your antenna system. You're doing great! 73,

Jim, K8OZ
Albuquerque, NM

Top Band Antenna by Mark, G0MGX and Vince G0ORC

Mike, I've been reading with interest your musings on top band antennas and have tried to build a replica of yours today with a fellow ham G0ORC. Thanks very much for the information and the link. You can see the results of my attempts here:

Construction: http://g0mgx.blogspot.co.uk/2012/08/top-band-what-happens-there-then.html

It Works!: http://g0mgx.blogspot.co.uk/2012/08/well-this-top-band-twig-does-it-work.html

Mark. G0MGX

Mike,

I know you have been in contact with my good friend Mark G0MGX but I felt I needed to say thanks and acknowledge your work on a 160m sloper.

It works very well here and, thanks to Mark who built several inductors until one gave us an SWR of 1.1 on the CW end of the band and also braised several copper rods together for form a reasonable earth under a large pine tree. He has passed on to me details of the website of K7MEM which may well inspire me to try a sloper for 80m as well.

I've always wanted a top band antenna but felt that I didn't have the room - but thanks to your idea and Mark's enthusiasm for the project I now have what I wanted - I'm being heard (and can hear) into European Russia with it so it certainly works!

Thanks again - I enjoyed your website very much. (Just heard A65BP as well!)

73, Vince G0ORC http://www.qrz.com/db/G0ORC

Further Developments of this antenna...

Another Top Band Aerial by MØMTJ

After reading the article "Top Band in a Small Garden" in the August 2012 edition of Practical Wireless Magazine ('PW'), I investigated further development of my Top Band Sloper / Inverted L Antenna (shown above).

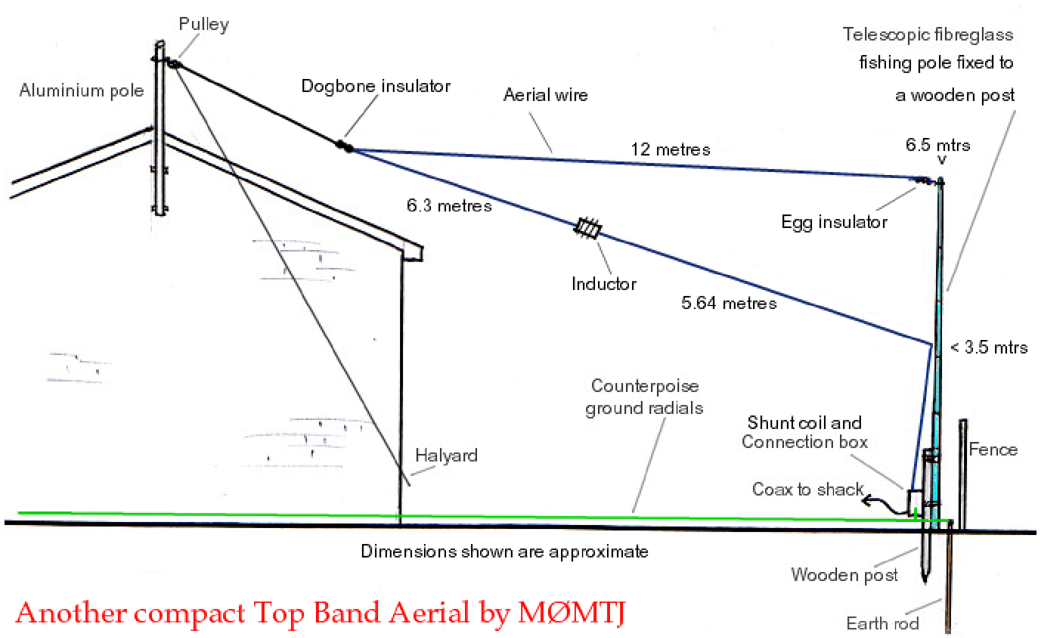
The article by Stuart Craigen G4GTX described a compact wire antenna for top band that could be accommodated in small gardens. The antenna is shunt fed at the base, the coax being connected across a 7 turn coil (wound on an off-cut of an empty silicone sealant cartridge), with the braid connected to the earth stake and radial ground wires. The centre conductor is connected to the aerial wire.

I could not quite accommodate the shape that Stuart suggested for the aerial wire, but it is very similar: For my version the feed point is at the bottom of the garden near the fence immediately adjacent the earth stake. The first section of aerial is about 9.14 metres long - the wire rises 3.5 metres vertically up the 6.5 metre tall telescopic pole, at the 3.5 metre point the wire is held in place on the mast by a small bungee and then folds over almost horizontally

and runs for a further 5.64 metres where it connects to the loading inductor.

The inductor consists of 36 turns of 18 swg (1.2mm diameter) enamelled copper wire on a 50mm diameter, lightweight plastic former (again made from an off-cut of an empty silicone sealant cartridge). After the inductor there is a further 6 metres (approx) of wire rising to a dog-bone insulator, fixed to the end of a length of para cord that runs up to the pulley shown in a previous photograph. From the dog-bone insulator the aerial wire runs back, in the opposite direction, for about 12 metres, returning to the top of the 6.5 metre tall mast at the bottom of the garden, tied off to an egg insulator which is itself fixed to the top of the mast by a very short length of para-cord fixed to the mast by a thick nylon cable tie.

If the wire dimensions are changed, the number of turns on the inductor will have to be changed accordingly. Similarly my antenna is located quite near the 80m/40m Inverted L and the interaction of the antenna affects the tuning and hence the number of turns required on the loading coil.



Another Top Band Aerial (drawing not to scale)
The inductor is 36 turns of 1.2mm diameter (18 swg) enamelled copper wire on a 2 inch former

With that arrangement there is about 27 metres of wire in the air. The point of resonance is 1900 kHz, but this can be adjusted by altering the number of turns on the inductor. As expected bandwidth is quite narrow. As with any antenna fed against ground the earthing needs to as extensive as possible - as noted previously, above. I suspect that it may be better that the top wire should be horizontal, or sloping slightly upwards, however with the available space and materials available the best that I could achieve had the top wire sloping slightly downwards to the post. Lowering the position of the dog-bone insulator or using a taller post could overcome this.

Photograph of the feed-point of the compact, folded, Top Band antenna showing the 7 turn shunt fed coil in the weatherproof housing. Nuts and bolts are stainless steel.

First Test: A brief on air test on 8th September 2012 between 2100 and 2130 UTC on 1.933 MHz brought in two prizes: Peter EI7JM near Malin Head and Tony M3LTD in Naseby, Leicestershire. EI7JM was a true 5/9 to me and he gave me a report of a true 5/9. M3LTD was 5/7. Many thanks to both stations for the useful contacts.

For different sized gardens the best idea might be to get as much aerial wire into the air and then make adjustments to the point of resonance by simply adjusting the number of turns on the inductor.

Practical Wireless Magazine
Obtain the article "Top Band in a Small Garden" by Stuart Craigen G4GTX from Practical Wireless Back Issues department

Stuart Craigen G4GTX comments:

Hi Mike, I have just been looking at your fascinating antenna page on top band antennas! Glad to see that you had a

go at building my shunt fed wire vertical that I did for Practical Wireless! I found it tremendous. A few weeks ago I was talking to G3YFN in Newcastle at about 4pm when I was called by G4BIM in the Isle of Wight! I also got a QSL 5/9 from Luxembourg!. Have fun.with it!

Thanks for the nice comments about my shunt fed 160m aerial. I enclose some QSL cards which you might find interesting to look at! Note the times of the QSO's and the reports! At night I have been told that I sound like the BBC from some European stations!!

Note G4BIM Isle of Wight 5/7 from Sunderland at 4.30 pm and Aberdeen at night. It certainly works for me. I think that the shunt feeding is the answer as it taps into the aerial at the 50 ohm point. Putting the loading coil away from the base should increase efficiency hence approx midway. A chap near Newcastle built one of these a few years ago and his groundwave signal was 5/9+20 here in Sunderland 12 miles away!!!
73
Stuart G4GTX

More ideas....

Adding Top Band to the 40m / 80m Inverted L antenna using a switchable loading coil:

Due to an aborted house move in 2010 I had removed all the antennas. While re-establishing the aerials in 2011, and considering space limitations, I decided to experiment with adding a loading coil to the 40m / 80m Inverted L aerial. The loading coil has a link wire to short it out of circuit when using the aerial for 80 metres and 40 metres. The link wire is removed when Top Band is required. The coil consists of approximately 37 turns wound on a piece of 68mm (2.8 inch approx) diameter PVC pipe:

Work In Progress! - Adding 160 metre loading coil to the 80m / 40m Inverted L Aerial.
The loading coil has a link wire to short it out of circuit when using the aerial for 80 metres and 40 metres.
The link wire is removed when Top Band is required.
The coil consists of approximately 37 turns wound on a piece of 68mm (2.7 inch approx) diameter PVC pipe.

More about the 80 / 40 metre Inverted L Aerial on Antennas Page 1 >

Simple Vertical Top Band Aerial Using A Fibreglass Telescopic Fishing Pole (Roach Pole)?

If there really is no space to accommodate a top band dipole, inverted V or even the inverted L above, then another option could be a simple vertical. Again based on a 10 metre long fibreglass roach pole, this could be installed as a

permanent aerial, or only deployed as and when required on a temporary and stealthy basis.

The 10 metre long fishing pole would be erected by standing it on the ground, using three or four nylon guy ropes as support, or tying it to a wooden ground stake driven into the ground. The vertical radiator would consist of about 9.5 metres of PVC covered wire fixed at the top of the pole and with a loading coil at the centre. As with the design above, the loading coil could be wound on a 5 cm diameter using 1.2 mm diameter enamelled copper wire. To make the former as light weight as possible, once again, the tube from an empty bathroom sealant (or silicone sealer etc) gun could be used. They are, conveniently, 50mm in diameter.

I have not experimented with the number of turns required for the centre loading coil, but from experience with the above aerial, the figure may lie somewhere between 50 and 100 turns.

The aerial would be fed with coaxial cable and would need a good earth rod at its base and a good number of ground radials, as along as possible.

Previous Top Band Aerial Experiments:

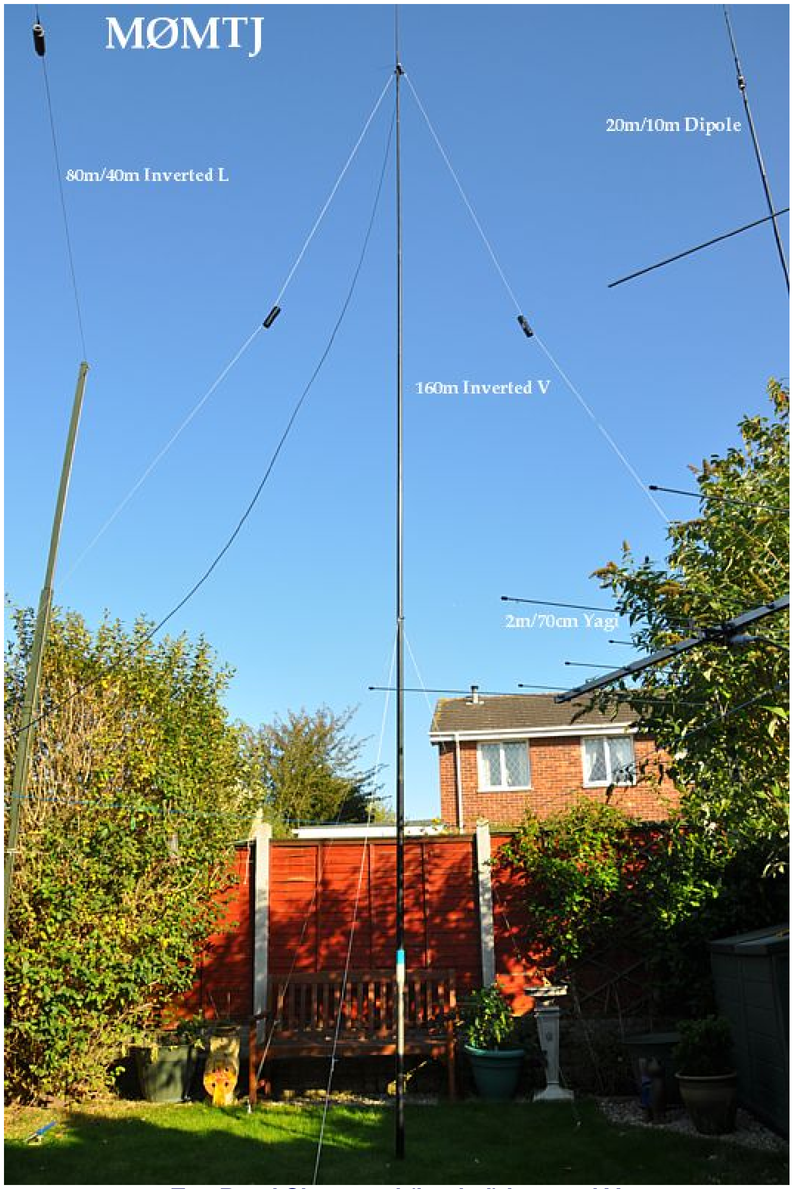
Top Band Inverted V

This is a considerably shortened dipole for 160 metres, using loading coils to reduce the length of each leg to about 7.5 metres length. Each coil is wound on a 5 cm diameter former and consists of approximately 120 turns of 1.2mm diameter enamelled copper wire. The dipole was arranged in an inverted V configuration.

Being as a dipole is a balanced aerial, it was fed at its centre using balanced twin feeder for lowest loss and, being balanced, lowest noise.

In this configuration it was very quiet, but did also appear to receive very well. At my QTH the noise on top band generally ranges from S7 to S9, on this inverted V the noise was S4 to S6. However it did not transmit well at all - I believe this to be not only because the dipole is very short (only 15m) but because the angle at which the wires at the top of the V was far too acute - only about 45 degrees. The angle at the top of the V really should be over well 90 degrees - maybe something like 110 degrees would be best. Clearly this seems to be a problem.

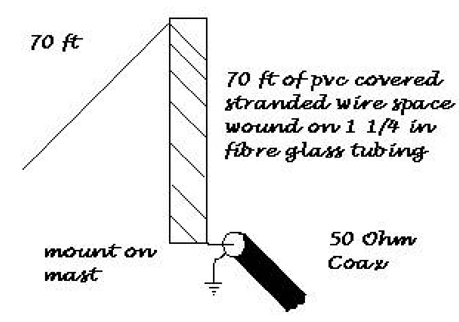
I had not got the space to separate the wires any further, but it was an interesting experiment that appeared to demonstrate that a balanced dipole fed with balanced twin feeder could help reduce noise. If more space was available this is an antenna that I would wish to pursue further.



Top Band Shortened (loaded) Inverted V

Short Base Loaded Sloper - a first attempt at a top band antenna

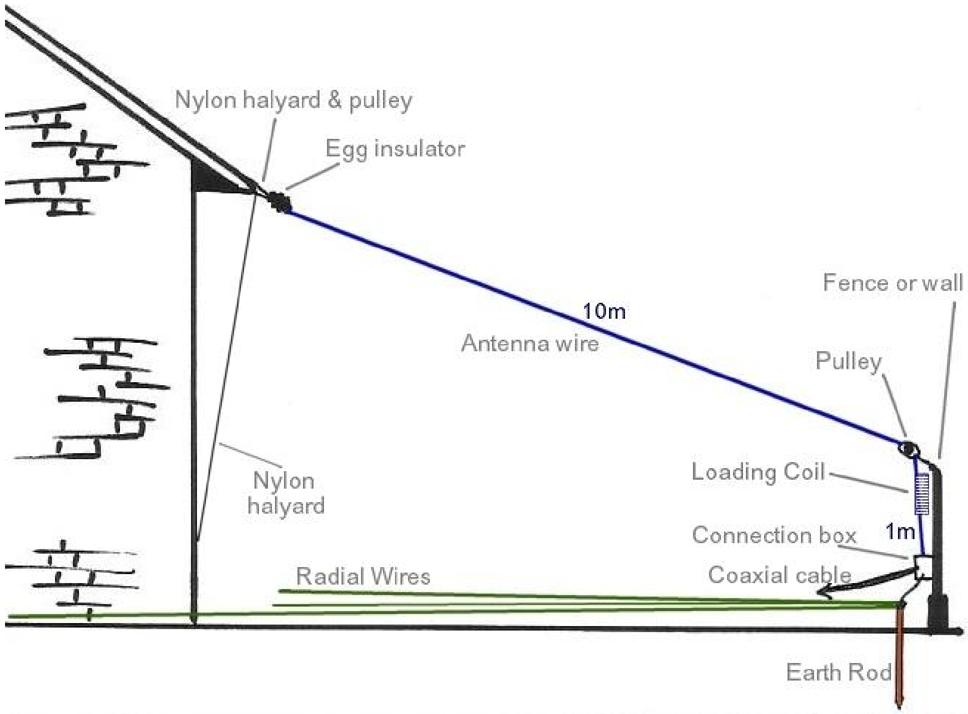
160m metres is probably the noisiest band, but I wanted to give it a go anyway even though space at my QTH is at a premium and fitting in a suitable antenna is quite challenging. The most promising candidate that I initially found, apart from small commercially available antennas, was the "Practical Antenna For 160 metres" described by Frank G3YCC and featured on the website of IW5EDI and linked to on the pages of www.dxzone.com



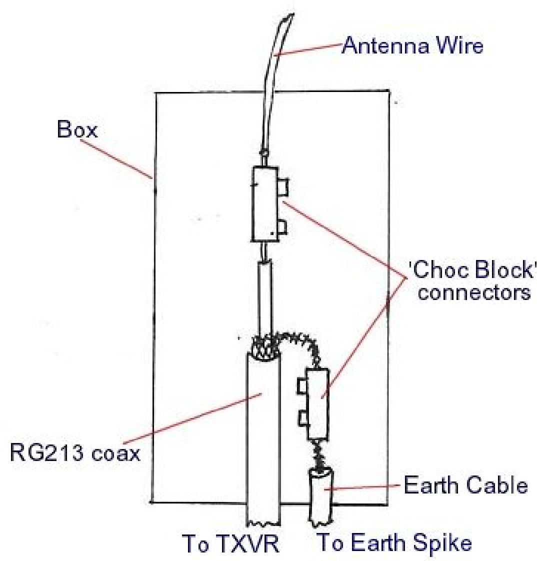
G3YCC Top Band Antenna

This Top Band antenna consists of 140 feet of wire, 70 feet space wound around a non-conductive (fibreglass) pole or tube about 6 feet long, with remainder forming a sloping wire falling back to near ground level. The antenna is UN-Balanced and is therefore fed with unbalanced coaxial cable, with the braid connected to a ground stake at the base of the aerial.

The above design is intended to have the coil section mounted on top of a mast or pole with the wire running downwards. I could not accommodate that arrangement, so I adapted the design to produce the antenna shown below:



The drawing above shows the loaded Top-Band Antenna - a first attempt at an aerial for 160m - consisting of the radiating top wire, a base loading coil, earth stake and additional earth radials that act as a counterpoise: The top wire is about 10 metres long and slopes down to the loading coil which consists of 64 turns of the aerial cable wound around a 4" diameter PVC pipe and then falls vertically for about 1 metre where it enters the connection box. The halyard arrangement allows the antenna wire to be quickly dropped for adjustment and then raised back into position. There is an earth rod at the base of the antenna connected to several ground radials and a second earth rod a few metres away.After performing some tests I find that it does work reasonably well for local contacts ground wave contacts around the town, but it could be better and is certainly very disappointing for longer distance work.



Above: The Connection Box

Read more developments here>

Efficiency

The aerial shown above is obviously very much shortened and therefore is very inefficient when compared to a full size resonant quater wave aerial. A shortened aerial still needs to make best use of the space - so the antenna wire

needs to be as long as possible. Resonance is adjusted by varying the inductance of the loading coil. Also it is necessary to use the largest earth system as is practicable to obtain the best possible efficiency.

Performance

In my configuration described above it is admittedly a very low efficiency antenna - but at least it gets one on Top Band! It's ok for local working around a town or a city, but it's certainly not a DX aerial by any stretch of the imagination. I could hear many stations 100 to 200 miles away, but they could not read my signals. For local ground wave work it was adequate.

I suspect that if the original design by G3YCC was employed, i.e. the coil mounted at the top of a pole and the loading wire running down, that it may work rather better than my implementation. The problem that my implementation has is that the loading coil is at the bottom of the aerial, near the ground. Better efficiency may be acheived with centre loading. The longer the radiating wire the better too.

More Details

The antenna was fed by coaxial cable from the shack in the bedroom at the front of the house to the feed point at the base of the fence at the bottom of the back garden. The coaxial cable enters a small plastic box, screwed to the fence post, where it is terminated: The outer conductor of the coax is connected to the earth cable with a 'chock block' connecter, the earth cable going to a four foot long earth rod hammered into the ground near by. The centre conductor of the coax is connected to the antenna cable also using a 'choc block' connector.

The antenna wire runs vertically up the fence for about 1 metre to the loading coil which consists of 64 turns of the antenna wire wound around a piece of 4 inch diameter PVC pipe. About 32 turns a close wound and the other 32 turns space wound; The inductance, and therefore the point of resonance could be easily adjusted by altering the spacing of the windings. Once set at the required point of resonance the windings can be held in place with duck tape.

The antenna wire exits the coil at the top and passes through a pully secured to the top of the fence and then slopes upwards for about 10 metres to the fixing point at a convenient point on the house, in this case the eaves. The end of the wire is tied off to a plastic 'egg insulator'. The egg insulator is tied to a nylon halyard wich passes through a second pully at the fixing point. This allows the antenna wire to be quickly dropped for adjustment and then raised back into position.

The earth system should be as extensive as possible for better efficiency; e.g. earth stake and a number earth radials, as long as possible around the garden to provide a counterpoise.

Link:

Visit www.g7klj.com - the website of 160 metre entusiast Steve G7KLJ

OTHER THINGS

Antennas for HF

There are dozens, if not hundreds, of antenna designs from which to choose. All have their own proponents. Some are genuinely good while others might be considered as nothing more than glorified dummy loads! The key thing for me was to choose the most effective an antenna that could fit within the constrains of my small back garden and also one that would not be too ugly.

I decided that wire antennas, made from PVC covered stranded wire, would be least objectionable on visual grounds. After all they look like glorified washing lines and almost everyone has a washing line**!**

Knots to use when fixing Wire Antennas

It's important to use the correct knot for the job. I find that the Bowline is very useful for fixing end, egg and dog-bone insulators to the ends of the wire and/or ropes. The Round Turn & Two Hitches, Anchor Bend and Buntline Hitch knots are very good for tying a rope to a pole or a mast. A Double Sheet Bend can join two pieces of rope together - even if they are of unequal size. 'Animated Knots' will show you how to do them: http://www.animatedknots.com

The antenna or antennas really are the key to an effective amateur radio station. The most expensive radio will be of little value unless it is used with the best possible and most effective antenna; so I had to set about finding the best antennas that I could accommodate for HF and VHF work.

The dilemma facing most radio amateurs is that antennas for HF are often large and difficult to accommodate in modern small back gardens. Additionally there may be objections on the grounds of visual impact. Some people do

not regard antennas as the beautiful creations that radio enthusiasts do!

Cables and Feeders

As I have learned by experience and from the tutorials I have studied as part of the licensing exam process, a very important consideration concerning the antenna system is the loss incurred in the cable that connects the radio to the antenna. A loss of 3dB sounds like a small amount when you say it quickly, but that equates to only HALF of your transmitter power reaching the aerial! We'd soon complain if our new 100 watt transceiver only produced 50 watts - so why stand the chance of losing this much power in the feed line?

Starting off as an M3 licensee I could only use 10dBw (10 watts) power at the antenna termination, so if I had a feeder with a loss of 3dB I would have to run the transmitter at 20 Watts to get 10 watts to the aerial!

Coaxial Cables

For HF using a single band resonant antenna, a dipole for example, Mini 8 or even RG58 is probably fine since the SWR should be between 1:1 and 2:1. However if one was to consider using the antenna on non resonant frequencies the VSWR will be higher, maybe very much higher, and the consequential losses in coaxial cable will be greatly magnified and power losses very significant. I did not want to run such an inefficient station.

For this reason I chose to use low loss RG213 coaxial cable for my Inverted L since I may need to use it on bands other than the 40 metre and 80 metres that it is intended for and where the SWR may be 4:1 or 5:1. RG213 will help keep feedline losses to a minimum. No lossy RG58 on Mini8 for me! Westflex 103 would be even better, of course.

For VHF and UHF I now consider Westflex103 as the minimum standard of cable to use, it's half the loss of even RG213. Losses at VHF are much higher than HF and at UHF they are even higher, so Westflex 103 helps preserve as much of that precious transmitter power as possible.

See more about Coaxial Cable Losses here >

Balanced Feeders = Low Noise

It's difficult to feed a centre fed wire dipole with RG213 or Westflex 103, both cables are really too thick and heavy. RG58 or Mini 8 are lighter and therefore more suitable for suspended wire dipoles, but to match the unbalanced coaxial cable to the balanced dipole would need a 1:1 'choke balun' at its centre, as I have learned. However, as mentioned above, when attempting to use the dipole at non-resonant frequencies the VSWR will be higher and the losses in the coaxial cable will be very much larger too, and hence much less of the precious transmitter power will be actually radiated by the antenna. Not an ideal situation

I have learned that the only really sensible way to feed dipole type antennas, which are 'balanced', is to use a balanced feeder such as 300 ohm ribbon cable, 450 ohm ladder line or the best option, it seems, might be 75 ohm Twin Feeder. All such twin feeders are extremely low loss, much much lower than any coaxial cable, so low that it could almost be considered lossless by comparison. Of course nothing is lossless, but twin feeder is as near as you'll get, so that's how I will feed my dipoles from now on! See the note on Doublet antennas below.

Tony Nailer of Spectrum Communications notes that: "75 ohm twin feeder is lower loss than coax. It allows the aerial to be properly balanced and the very close spacing of the wires prevents pickup or radiation from the feeder. It does not need to be spaced off, unlike ribbon feeder. Use of twin feeder makes this aerial much lower noise than one fed with coax. Also importantly it generates less TVI !!   Note that the [trapped dipole] aerial is generally 72 ohms, and will need to be used with an ATU with transistorised rigs which are unforgiving about SWR mismatches."

Spectrum Communications are now supplying a new design of top quality, very low loss, twin feeder. It is rated at 2kW at 100 ohms. It can be supplied by 100 metre reel or by the meter, or in various lengths with the ends expertly terminated and made off. I can confirm the superior quality of this product and its low noise properties.

Spectrum Communications also supply a very high quality, well made 1:1 Balun that is perfect for connecting the twin feeder to the unbalanced input of an A.T.U. of transceiver.

Doublet or Dipole (Horizontal or Sloper)

I have also experimented with a second HF antenna - the 'doublet' style antenna. I fed this with low loss twin feeder and cut it for the lowest frequency of operation, in my case 20 metres (14 MHz).

Some initial experiments have shown that it is very effective on 20 metres, better than my Inverted L - which is designed essentially for 80m and 40m.

In theory a doublet antenna, when fed by twin feeder (NOT coaxial cable) and matched at the transmitter end via a

1:1 balun and an ATU (or to use a more correct term, Antenna Matching Unit) at the transceiver should be able to work on all bands with a higher frequency than the band that it is cut for.

On other bands such as 17m (18 MHz), 15m (21 MHz), 12m (24 MHz) and 10m 28 MHz) the doublet showed generally lower VSWR than the Inverted L .... however (and here is a nice lesson) it is actually not quite as effective as the Inverted L! I think that size may matter here - the overall length of the Inverted L is much longer.

This short 14 MHz doublet is only about 10 metres in total length and was suspended at about 25 feet high at one end from the same fibreglass pole fixed at the apex of the roof and taken down to another 16 foot high wooden pole installed on the other side of the back garden in somewhat of a 'sloper' style.

Trapped Horizontal Dipole or Vertical Antenna for 20m / 10m

I also experimented with a trapped wire dipole cut to be resonant for 20 metres and 10 metres, again fed with twin feeder and matched at the radio end via a 1:1 balun and the ATU (AMU !).

I may also try an antenna for 20m / 15m and 10m in a Vertical 'ground plane' arrangement which should give a lower angle of radiation than a horizontal dipole - therefore better for longer distance DX.

At the moment I am using the 20m / 10m trapped dipole in a rather unorthodox arrangement. I have installed a fibreglass fishing pole, mounted vertically on a stake on one side of the garden. Most of the wire dipole is fixed to the vertical pole, but being as the dipole is somewhat longer than 7 metres, a portion of the wire runs away from the pole horizontally along a fence panel about 1.5 meters above ground level. It's vaguely L shaped, but mostly vertical which should help with the angle of radiation. It seems to work very well indeed - I like the mostly vertical idea.
The antenna can be seen on this page >

Other Dipoles:

Spectrum Communications can supply a full size W3DZZ style antenna with a 7MHz trap for use on 40m and 80m and usable on 20m, 15m and 10m. A half size version with a 14 MHz trap for use on 40m and 20 metres, plus 15m and 10m is also available. As a special order an even shorter version using a 28 MHz trap is available for 20 metres and 10 metres. http://www.spectrumcomms.co.uk/G2DYM.htm Al versions designed to be used with balanced line feeder - lince they are balanced aerials - for low noise and lowest loss.

PDF Document - The W3DZZ Antenna -
http://www.users.icscotland.net/~len.paget/GM0ONX%20trap%20dipole.pdf (But rather than using coaxial cable with a 'choke balun' at the centre of the dipole, try using twin feeder with the Choke Balun at the radio end for less power loss!)

Links

Enamelled copper wire supply: http://www.esr.co.uk/electronics/cable-copper.htm

Loading coil calculators: http://www.k7mem.com/Electronic_Notebook/antennas/shortant.html

Ring Core Calculator: http://www.dl5swb.de/html/mini_ring_core_calculator.htm

Vertical Antenna For 50 MHz, 144 MHz and 430 MHz

Watson W-2000 on Telescopic Mast at the lowest position
more on this page

OTHER ANTENNAS

Our good friend in Australia Felix Scerri, VK4FUQ, uses Inverted V antennas but also highly recommends the Quad Loop style antenna for HF work. These are well worth investigating, and you can read more here: Antennas 3 see the antennas at the MØMTJ QTH here with many more antenna ideas on Antennas 4 and the Links Page here and here

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AERIALS (ANTENNAS) 2

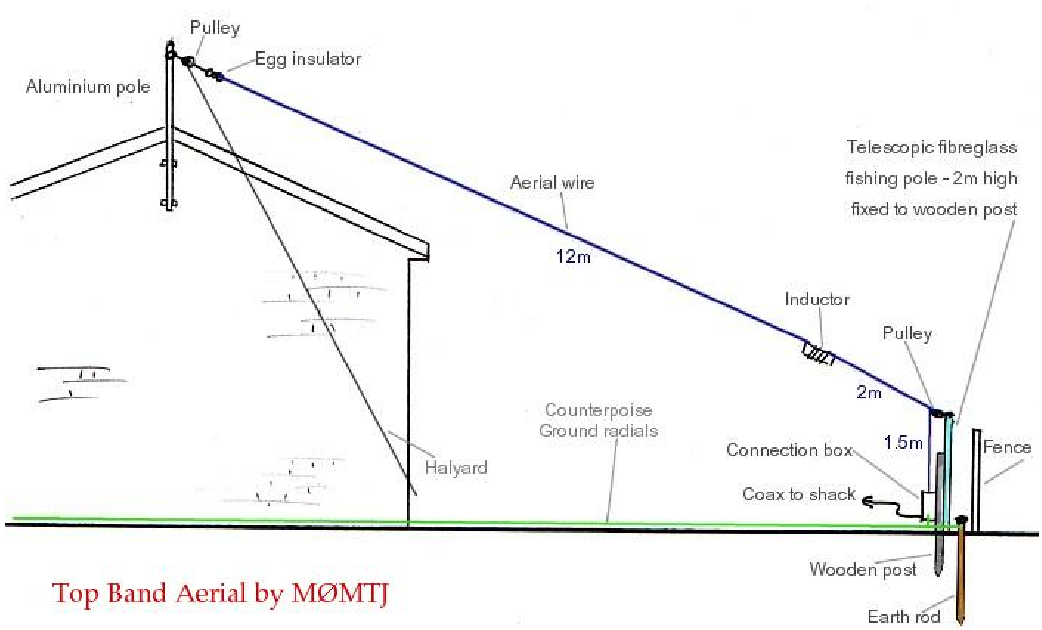
Antennas 1 | **Antennas 3** | **Antennas 4** | **Antennas 5** | **Antennas 6** | **Antennas 7**

Compact Top Band Antenna - An Inverted L for stealth with low(ish) visual impact

With a small back garden there is no way that I could accommodate an aerial for the 160m band that would be anything approaching full size. A full size dipole would be about 65 metres long and would need to be mounted at a very good height to be at its most effective. A full size vertical 1/4 wave would be about 37.5 meters tall. Impossible! Bending a 1/4 wave wire into an inverted L would still result in a very long wire - say 10 metres vertically and 27.5 metres horizontally. Still too large.

Full size top band antennas are big, far too big for my small plot, so I have tried a few different shortened 160m aerials. I really would prefer to use a balanced dipole not only for the radiation efficiency, but just as importantly for the lower noise on receive - like a ground mounted vertical aerial an inverted L can be rather noisy on RX. However I have to settle for a compromise, so shown in the drawings and photographs below is my current top band aerial, along with some previous experiments and ideas further down the page.

This incarnation of my Top Band aerial takes two forms. A compact Inverted L and, in its lower position, a less conspicuous sloping wire, shown below:



General layout of Top Band Aerial with fibreglass pole retracted to a height of 2 metres
Wire lengths are approximate: Inductor 5cm dia with approx 40 turns of 0.9mm e.c.w.

G-WHIP ANTENNAS

My first experiments were with a base loaded sloper which worked ok-ish for local ground wave, but could have been better. The first weak link that I wanted to change was moving the base loading coil further up the aerial wire so that it would be positioned on the more horizontal section.

It was also very low, so could surely benefit from some additional vertical height. However I could not realistically erect another permanent pole in the garden for fear of upsetting the XYL!

Therefore I decided that I needed a design that could be semi-permanent and offer two slightly different configurations: The idea is that, as a sloping wire, the aerial can be left in place at all times for RX and still be operable on TX. Since it is essentially just a wire sloping from fence height (2m) up to the roof apex it has fairly minimal visual impact. Alternatively, when required - at night - the telescopic pole can be extended to transform the aerial into the larger Inverted L.

The Earth and Radials: The aerial is fed against ground, so the ground needs to be as good as possible. At the base of the aerial a copper earth rod is driven into the ground. Additional ground radial wires are also added to provide a counterpoise and help reduce earth loss. The more the merrier.

The Support: A 10 metre long telescopic fibreglass fishing pole is used as part of the support. A wooden post was driven into the ground, adjacent to the earth rod. The connector box is screwed on to the post and the fishing pole was fixed to the post using nylon straps.

Since the top sections of a fishing pole are too thin to support the aerial wire, the last four sections were removed, leaving the pole 6 metres in length, which is a respectable height in a small back garden, though being even taller would be better.

A small lightweight pulley is fixed to the top of the fibreglass pole using two nylon ties - as seen in the photograph. As a sloping wire, the fishing pole is collapsed to 2m in height while being extended to 6 metres when being used as the 'full' Inverted L. The pole is quite flexible and so will tend to bend quite noticeably when 6 metres long with the wire attached to the top. This could be remedied by adding a back guy rope of required.

The far end of the aerial wire is tied to a egg type insulator and nylon halyard which is suspended through a pulley on a pole attached near the apex of the roof. The nylon halyard is tied off on a cleat hook near ground level to enable easy raising and lowering of the aerial wire.

The Wire: Aerial wire is PVC covered stranded wire of about 16/18 swg http://www.whwestlake.co.uk. The wires were cut for the maximum length that could be fitted into the available space - so as much wire was in the air as possible. This was about 3.5 metres from the feed point to inductor and around 12 to 13 metres from the inductor to the far end.

(If you make one of these get the vertical portion as high as possible and the horizontal section as long as possible and reduce the coil's inductance accordingly)**.**

The Inductor and Resonance:

The resonance of the aerial system was adjusted not by altering the length of the wires, but by changing the inductance of the loading coil.

I had some 0.9mm (20 s.w.g.) enamelled copper wire on a reel, so I used that to wind the coil. The coil former is 5cm in diameter and about 15 cm long, cut from an empty tube of silicone bath sealant (the 'gun' type). Two holes are drilled in the former for the fixing bolts and wing nuts that secure the aerial and coil wires.

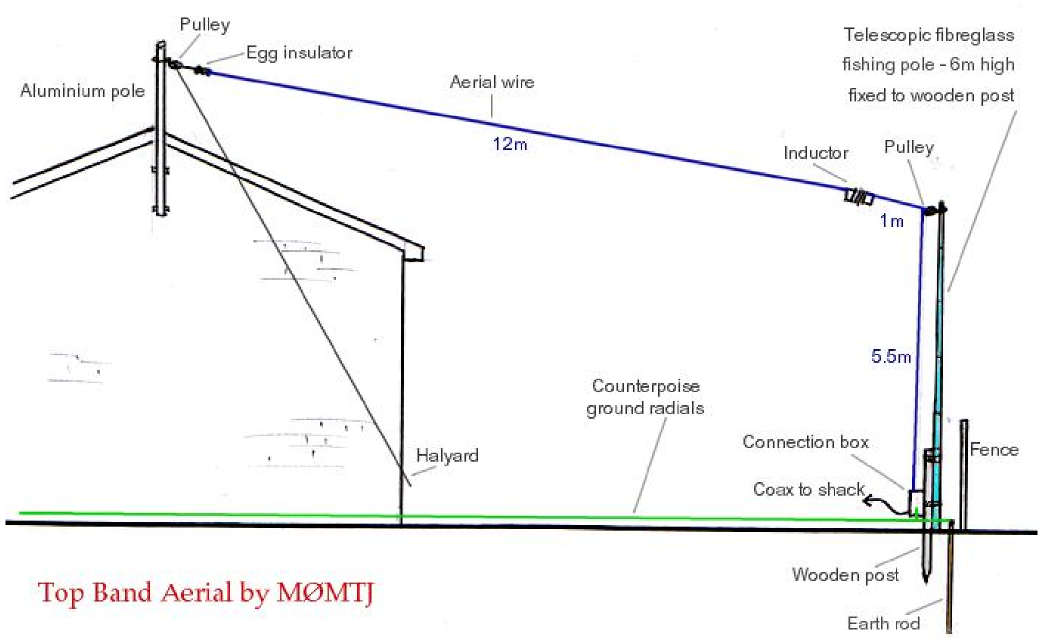
I used an MFJ antenna analyzer to check resonance and adjust the number of turns. Initially the coil was wound with 60 turns, but the resonance was well below 1800 kHz. Turns were gradually removed until resonance was around 1940 kHz, leaving 39 turns on the coil. (Thicker e.c.wire might have been better, I would have preferred to use something like 18.swg 1.2mm diameter and this may possibly get changed in the future)

Enamelled copper wire:
http://www.esr.co.uk/electronics/cable-copper.htm

When the adjustments were finished the aerial wires and coil wires are terminated with lugs and fixed in place with the bolts and wing nuts. The winding was also covered in duck tape. All exposed connections should be suitably protected against the weather for a permanent installation.

When setting up any aerial an antenna analyzer is extremely useful - allowing all the measurements to be done in the garden or back yard thereby simplifying and speeding up the process considerably. These simple

measurements can be made using the transceiver and VSWR meter, though that is obviously less convenient and will involve transmitting regular short burst of carrier, so it's very important to ensure that the power used is the absolute minimum and that the frequency being used is clear.



General layout of Top Band Aerial with a fibreglass pole extended to a height of 6 metres
Wire lengths are approximate: Inductor 5cm dia with approx 39 turns of 0.9mm e.c.w.

To transform the aerial to the Inverted L format (shown in the above diagram) I envisaged that changing the first length of wire, from a 3.5 metre length to 6.5 metre length, and the inductor would be necessary. I had assumed that a coil with less inductance (fewer turns) would be required due to the longer length of aerial wire used in the Inverted L arrangement.

I was, however, proved wrong. On first attempt I left the original coil in place, just adding the longer wire section (from connection box to coil) and raising the pole to its full 6 metres. The point of resonance was only about 20 kHz away from where it was as a sloper.

This, I think, can be explained by the fact that in the sloper configuration, the wire is close to the ground, other objects and vegetation which will in effect add loading to the aerial, Consequently a loading coil with less inductance than might otherwise be expected is required. So, by happy coincidence, the same coil is also suitable for the longer wire that is at a greater height (and therefore is influenced less by ground loading).

This, quite by chance, made the swap from Sloper to Inverted L a little easier since there was no need to wind a second coil - the change being made by merely adding the longer first wire section and pushing up the pole to its full 6 metre height.

If there are no concerns or objections to installing a tall pole at the bottom of the garden, then the Inverted L arrangement could be left as a permanent installation. In that case the pole need not be a fibreglass fishing pole, although it is still an attractive lightweight method, instead a couple of 3 metre long sections of treated timber could be joined together to form a 6 metre high post - the higher and longer the better though!

These links may be useful in helping to calculate loading coils:

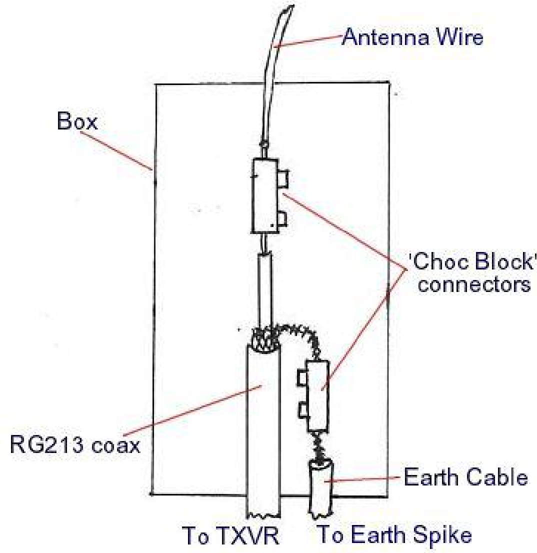
Antenna Loading Coil Calculator : http://eweb.chemeng.ed.ac.uk/jack/radio/software/loading.html

Coil winding design program : http://ecosse.org/jack/radio/software/newcoil3.html

Loaded dipole calculator by K7MEM : http://www.k7mem.com/Electronic_Notebook/antennas/shortant.html

Ring Core Calculato r: http://www.dl5swb.de/html/mini_ring_core_calculator.htm

Top Band Inverted L - photograph showing the wooden support post with telescopic pole attached with connection box, cables and earth rod. The cable entering from the left is the earthing strap which is connected to ground rods and radial wires. The coaxial feeder cable exits from the bottom right of the box and is wound around a length of white plastic pipe to form a simple RF Choke.



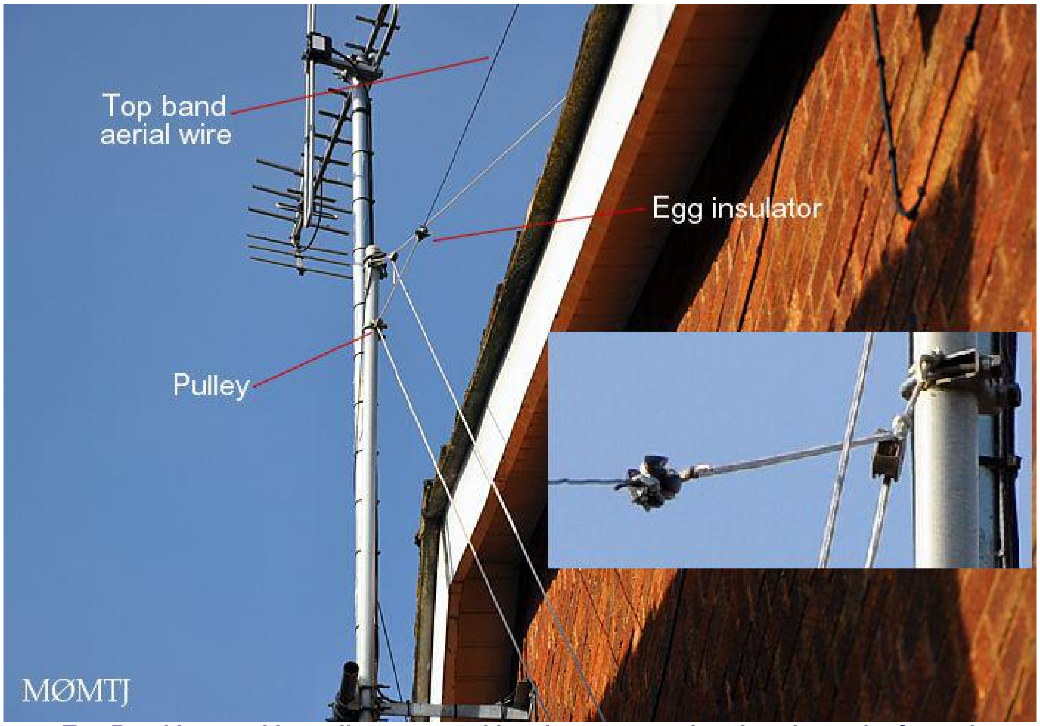
My original implementation which used 'choc block' connectors. The final design has all soldered joints with a stainless steel bolt and wing not at the top of the connecting box.

Top Band Inverted L - pulley on top of the 6m telescopic pole

Top Band Inverted L - loading inductor.

This is the unfinished coil, the connections on the left are properly finished off using lugs, but the connections on the right are unfinished to allow adjustment of the number of turns. When that is settled the final lug is soldered to the end of the enamelled copper wire and held in place with the bolt and wing nut. The coil is 39 turns of 0.9mm e.c.w., wound on a 5cm diameter former made out of an empty silicone bathroom sealant tube. (I would have preferred to use slightly thicker e.c.w. of about 18 swg 1.2mm diameter, so that may get changed in the future)

Enamelled copper wire:
http://www.sycomcomp.co.uk
http://www.esr.co.uk/electronics/cable-copper.htm



Top Band Inverted L - pulley, rope and insulator supporting the wire at the far end

Top Band Inverted L - supported by a 6m long fibrelass (roach) pole

Top Band Inverted L - looking up!

The photo exaggerates the bend a little, but it's not enough to worry about. The bend could easily be corrected by adding a back guy to pull the pole back towards the vertical position, but for this job it's fine as it is.

DOES IT WORK?

Yes! This aerial does work, I am glad to say!

It works better than my initial short sloping wire shown further down this page, which is what one would expect!

Rather than merely settling for a local ground wave signal I was very pleased to contact Top Band enthusiast Steve G7KLJ on my first attempt. Steve is 170 miles distant from me and the night time sky wave provided a pretty good result. G7KLJ gave me a 5 / 8 with my 100 watts on 1843kcs using my small aerial. I gave G7KLJ 5 / 9+10 with Steve's large doublet and 400 watts (lovely audio too Steve!).

Admittedly that's potentially a 16dB difference, which is pretty huge, but G7KLJ had the benefit of 300 more watts - that's a 6dB advantage. It also depends on how the individual S meters compare. Steve seemed to indicate that his S meter was a bit on the lazy side - 1 S Point pessimistic? But maybe my S meter similarly pessimistic?

Compared to a full size inverted L my loaded aerial is less than half the size and is obviously going to lose out, but by how much? Half the size, half the effective power - 3dB down? Probably a lot more - 6dB? There's one S point lost already (Who wants to bet that it's a lot more than that?). Since I have a ground system that is far from ideal there's another few dB's lost - another 6dB? That would be 2 S Points lost before taking into account anything else. This is all pure guesswork and speculation admittedly and probably quite groundless (almost literally in my case), and might best be described as pointless ramblings! (Where did the delete key go?) The pessimist? The realist?

The only thing proved by this single event is that my aerial radiates at least something useful - and that G7KLJ has a great station! www.g7klj.com

Droitwich

OK so it's not Droitwich, but it does work and gets me on Top Band when otherwise there would be no chance.

I am happy - but as with anything improvements can always be made. The aerial could be taller perhaps, though I cannot make it any longer. The earth system could be far far better, though I would struggle to accommodate any improvements at the present QTH. I could use better coaxial cable and also (importantly) attempt to lower the received noise by experimenting with chokes or burying the feeder to reduce common mode currents.

Plenty to think about and plenty to play with!

Important notes on effective Grounding by Jim K8OZ

Mike - I was reading about your work on the 160 meter Inverted L, and it makes me want to go out and build some more antennas! Congratulations. Your story is fascinating, and very well documented.

The only thing I can offer as a suggestion is to get as much radial wire along the edge of your property as possible (assuming your XYL will not allow you to bury radial wire all over your yard). Even if you can only run multiple wires 1/8th of a meter apart from each other, and parallel to each other, your losses will be reduced. The ground losses have quite an impact on your transmitted signal, so any wire you can "hide" along the edge of your property will help improve your signal strength - little, by little...! { It may also affect your resonant frequency slightly, but that's easy to deal with by adjusting with an antenna tuner or slightly changing the loading coil. }

Good luck OM, and keep up the refinements on your antenna system. You're doing great! 73,

Jim, K8OZ
Albuquerque, NM

Top Band Antenna by Mark, G0MGX and Vince G0ORC

Mike, I've been reading with interest your musings on top band antennas and have tried to build a replica of yours today with a fellow ham G0ORC. Thanks very much for the information and the link. You can see the results of my attempts here:

Construction: http://g0mgx.blogspot.co.uk/2012/08/top-band-what-happens-there-then.html

It Works!: http://g0mgx.blogspot.co.uk/2012/08/well-this-top-band-twig-does-it-work.html

Mark. G0MGX

Mike,

I know you have been in contact with my good friend Mark G0MGX but I felt I needed to say thanks and acknowledge your work on a 160m sloper.

It works very well here and, thanks to Mark who built several inductors until one gave us an SWR of 1.1 on the CW end of the band and also braised several copper rods together for form a reasonable earth under a large pine tree. He has passed on to me details of the website of K7MEM which may well inspire me to try a sloper for 80m as well.

I've always wanted a top band antenna but felt that I didn't have the room - but thanks to your idea and Mark's enthusiasm for the project I now have what I wanted - I'm being heard (and can hear) into European Russia with it so it certainly works!

Thanks again - I enjoyed your website very much. (Just heard A65BP as well!)

73, Vince G0ORC http://www.qrz.com/db/G0ORC

Further Developments of this antenna...

Another Top Band Aerial by MØMTJ

After reading the article "Top Band in a Small Garden" in the August 2012 edition of Practical Wireless Magazine ('PW'), I investigated further development of my Top Band Sloper / Inverted L Antenna (shown above).

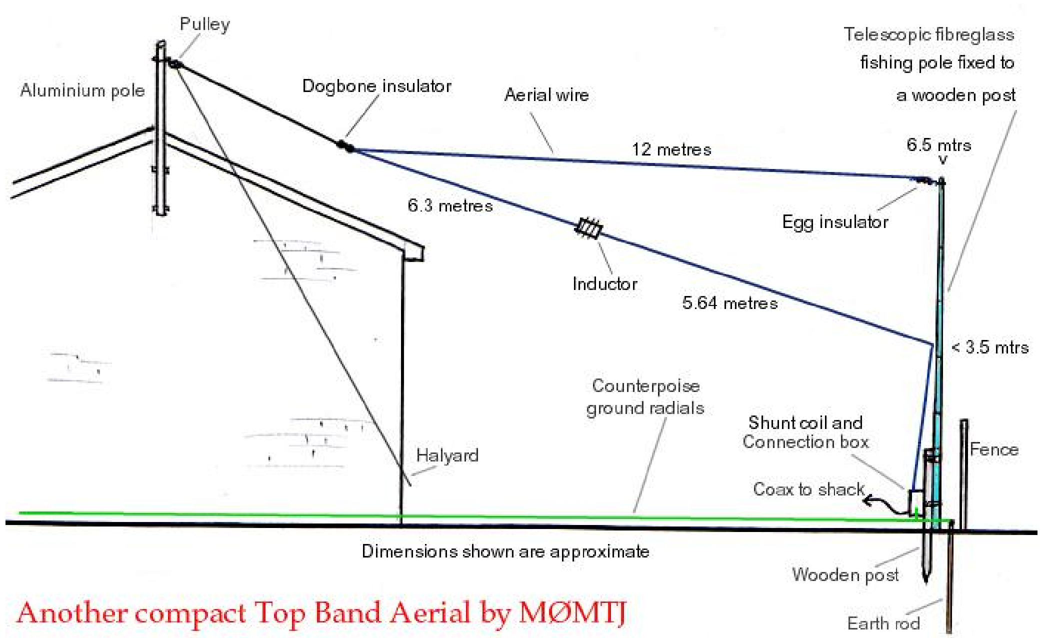
The article by Stuart Craigen G4GTX described a compact wire antenna for top band that could be accommodated in small gardens. The antenna is shunt fed at the base, the coax being connected across a 7 turn coil (wound on an off-cut of an empty silicone sealant cartridge), with the braid connected to the earth stake and radial ground wires. The centre conductor is connected to the aerial wire.

I could not quite accommodate the shape that Stuart suggested for the aerial wire, but it is very similar: For my version the feed point is at the bottom of the garden near the fence immediately adjacent the earth stake. The first section of aerial is about 9.14 metres long - the wire rises 3.5 metres vertically up the 6.5 metre tall telescopic pole, at the 3.5 metre point the wire is held in place on the mast by a small bungee and then folds over almost horizontally

and runs for a further 5.64 metres where it connects to the loading inductor.

The inductor consists of 36 turns of 18 swg (1.2mm diameter) enamelled copper wire on a 50mm diameter, lightweight plastic former (again made from an off-cut of an empty silicone sealant cartridge). After the inductor there is a further 6 metres (approx) of wire rising to a dog-bone insulator, fixed to the end of a length of para cord that runs up to the pulley shown in a previous photograph. From the dog-bone insulator the aerial wire runs back, in the opposite direction, for about 12 metres, returning to the top of the 6.5 metre tall mast at the bottom of the garden, tied off to an egg insulator which is itself fixed to the top of the mast by a very short length of para-cord fixed to the mast by a thick nylon cable tie.

If the wire dimensions are changed, the number of turns on the inductor will have to be changed accordingly. Similarly my antenna is located quite near the 80m/40m Inverted L and the interaction of the antenna affects the tuning and hence the number of turns required on the loading coil.



Another Top Band Aerial (drawing not to scale)
The inductor is 36 turns of 1.2mm diameter (18 swg) enamelled copper wire on a 2 inch former

With that arrangement there is about 27 metres of wire in the air. The point of resonance is 1900 kHz, but this can be adjusted by altering the number of turns on the inductor. As expected bandwidth is quite narrow. As with any antenna fed against ground the earthing needs to as extensive as possible - as noted previously, above. I suspect that it may be better that the top wire should be horizontal, or sloping slightly upwards, however with the available space and materials available the best that I could achieve had the top wire sloping slightly downwards to the post. Lowering the position of the dog-bone insulator or using a taller post could overcome this.

Photograph of the feed-point of the compact, folded, Top Band antenna showing the 7 turn shunt fed coil in the weatherproof housing. Nuts and bolts are stainless steel.

First Test: A brief on air test on 8th September 2012 between 2100 and 2130 UTC on 1.933 MHz brought in two prizes: Peter EI7JM near Malin Head and Tony M3LTD in Naseby, Leicestershire. EI7JM was a true 5/9 to me and he gave me a report of a true 5/9. M3LTD was 5/7. Many thanks to both stations for the useful contacts.

For different sized gardens the best idea might be to get as much aerial wire into the air and then make adjustments to the point of resonance by simply adjusting the number of turns on the inductor.

Practical Wireless Magazine
Obtain the article "Top Band in a Small Garden" by Stuart Craigen G4GTX from Practical Wireless Back Issues department

Stuart Craigen G4GTX comments:

Hi Mike, I have just been looking at your fascinating antenna page on top band antennas! Glad to see that you had a

go at building my shunt fed wire vertical that I did for Practical Wireless! I found it tremendous. A few weeks ago I was talking to G3YFN in Newcastle at about 4pm when I was called by G4BIM in the Isle of Wight! I also got a QSL 5/9 from Luxembourg!. Have fun.with it!

Thanks for the nice comments about my shunt fed 160m aerial. I enclose some QSL cards which you might find interesting to look at! Note the times of the QSO's and the reports! At night I have been told that I sound like the BBC from some European stations!!

Note G4BIM Isle of Wight 5/7 from Sunderland at 4.30 pm and Aberdeen at night. It certainly works for me. I think that the shunt feeding is the answer as it taps into the aerial at the 50 ohm point. Putting the loading coil away from the base should increase efficiency hence approx midway. A chap near Newcastle built one of these a few years ago and his groundwave signal was 5/9+20 here in Sunderland 12 miles away!!!
73
Stuart G4GTX

More ideas....

Adding Top Band to the 40m / 80m Inverted L antenna using a switchable loading coil:

Due to an aborted house move in 2010 I had removed all the antennas. While re-establishing the aerials in 2011, and considering space limitations, I decided to experiment with adding a loading coil to the 40m / 80m Inverted L aerial. The loading coil has a link wire to short it out of circuit when using the aerial for 80 metres and 40 metres. The link wire is removed when Top Band is required. The coil consists of approximately 37 turns wound on a piece of 68mm (2.8 inch approx) diameter PVC pipe:

Work In Progress! - Adding 160 metre loading coil to the 80m / 40m Inverted L Aerial.
The loading coil has a link wire to short it out of circuit when using the aerial for 80 metres and 40 metres.
The link wire is removed when Top Band is required.
The coil consists of approximately 37 turns wound on a piece of 68mm (2.7 inch approx) diameter PVC pipe.

More about the 80 / 40 metre Inverted L Aerial on Antennas Page 1 >

Simple Vertical Top Band Aerial Using A Fibreglass Telescopic Fishing Pole (Roach Pole)?

If there really is no space to accommodate a top band dipole, inverted V or even the inverted L above, then another option could be a simple vertical. Again based on a 10 metre long fibreglass roach pole, this could be installed as a

permanent aerial, or only deployed as and when required on a temporary and stealthy basis.

The 10 metre long fishing pole would be erected by standing it on the ground, using three or four nylon guy ropes as support, or tying it to a wooden ground stake driven into the ground. The vertical radiator would consist of about 9.5 metres of PVC covered wire fixed at the top of the pole and with a loading coil at the centre. As with the design above, the loading coil could be wound on a 5 cm diameter using 1.2 mm diameter enamelled copper wire. To make the former as light weight as possible, once again, the tube from an empty bathroom sealant (or silicone sealer etc) gun could be used. They are, conveniently, 50mm in diameter.

I have not experimented with the number of turns required for the centre loading coil, but from experience with the above aerial, the figure may lie somewhere between 50 and 100 turns.

The aerial would be fed with coaxial cable and would need a good earth rod at its base and a good number of ground radials, as along as possible.

Previous Top Band Aerial Experiments:

Top Band Inverted V

This is a considerably shortened dipole for 160 metres, using loading coils to reduce the length of each leg to about 7.5 metres length. Each coil is wound on a 5 cm diameter former and consists of approximately 120 turns of 1.2mm diameter enamelled copper wire. The dipole was arranged in an inverted V configuration.

Being as a dipole is a balanced aerial, it was fed at its centre using balanced twin feeder for lowest loss and, being balanced, lowest noise.

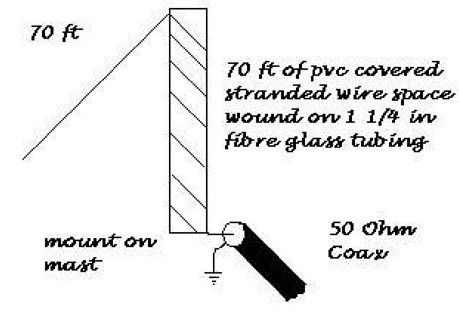
In this configuration it was very quiet, but did also appear to receive very well. At my QTH the noise on top band generally ranges from S7 to S9, on this inverted V the noise was S4 to S6. However it did not transmit well at all - I believe this to be not only because the dipole is very short (only 15m) but because the angle at which the wires at the top of the V was far too acute - only about 45 degrees. The angle at the top of the V really should be over well 90 degrees - maybe something like 110 degrees would be best. Clearly this seems to be a problem.

I had not got the space to separate the wires any further, but it was an interesting experiment that appeared to demonstrate that a balanced dipole fed with balanced twin feeder could help reduce noise. If more space was available this is an antenna that I would wish to pursue further.

Top Band Shortened (loaded) Inverted V

Short Base Loaded Sloper - a first attempt at a top band antenna

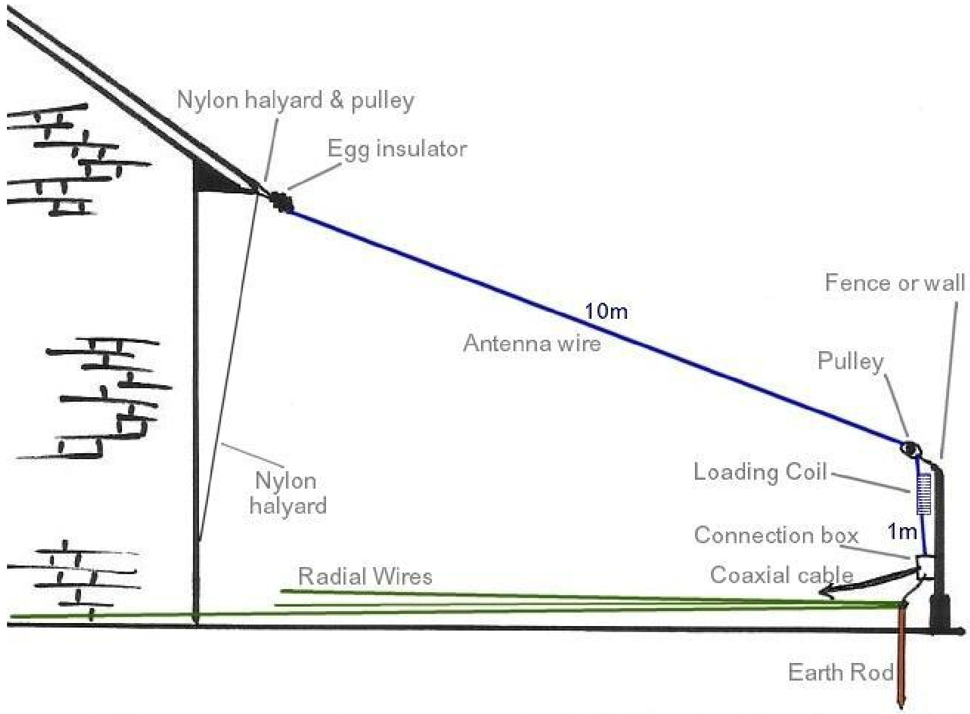
160m metres is probably the noisiest band, but I wanted to give it a go anyway even though space at my QTH is at a premium and fitting in a suitable antenna is quite challenging. The most promising candidate that I initially found, apart from small commercially available antennas, was the "Practical Antenna For 160 metres" described by Frank G3YCC and featured on the website of IW5EDI and linked to on the pages of www.dxzone.com



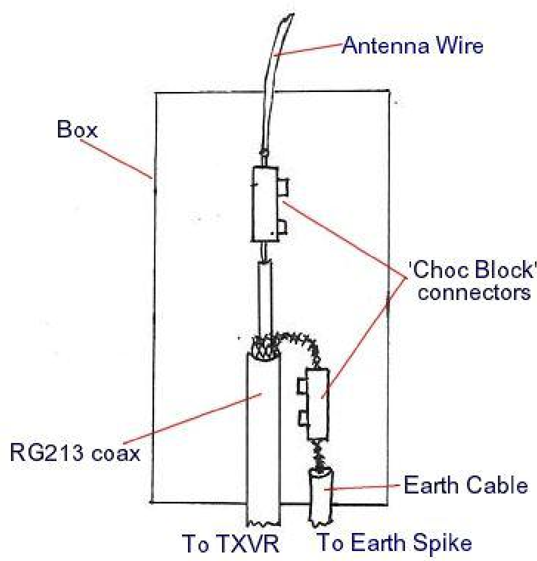
G3YCC Top Band Antenna

This Top Band antenna consists of 140 feet of wire, 70 feet space wound around a non-conductive (fibreglass) pole or tube about 6 feet long, with remainder forming a sloping wire falling back to near ground level. The antenna is UN-Balanced and is therefore fed with unbalanced coaxial cable, with the braid connected to a ground stake at the base of the aerial.

The above design is intended to have the coil section mounted on top of a mast or pole with the wire running downwards. I could not accommodate that arrangement, so I adapted the design to produce the antenna shown below:



The drawing above shows the loaded Top-Band Antenna - a first attempt at an aerial for 160m - consisting of the radiating top wire, a base loading coil, earth stake and additional earth radials that act as a counterpoise: The top wire is about 10 metres long and slopes down to the loading coil which consists of 64 turns of the aerial cable wound around a 4" diameter PVC pipe and then falls vertically for about 1 metre where it enters the connection box. The halyard arrangement allows the antenna wire to be quickly dropped for adjustment and then raised back into position. There is an earth rod at the base of the antenna connected to several ground radials and a second earth rod a few metres away.After performing some tests I find that it does work reasonably well for local contacts ground wave contacts around the town, but it could be better and is certainly very disappointing for longer distance work.



Above: The Connection Box

Read more developments here>

Efficiency

The aerial shown above is obviously very much shortened and therefore is very inefficient when compared to a full size resonant quater wave aerial. A shortened aerial still needs to make best use of the space - so the antenna wire

needs to be as long as possible. Resonance is adjusted by varying the inductance of the loading coil. Also it is necessary to use the largest earth system as is practicable to obtain the best possible efficiency.

Performance

In my configuration described above it is admittedly a very low efficiency antenna - but at least it gets one on Top Band! It's ok for local working around a town or a city, but it's certainly not a DX aerial by any stretch of the imagination. I could hear many stations 100 to 200 miles away, but they could not read my signals. For local ground wave work it was adequate.

I suspect that if the original design by G3YCC was employed, i.e. the coil mounted at the top of a pole and the loading wire running down, that it may work rather better than my implementation. The problem that my implementation has is that the loading coil is at the bottom of the aerial, near the ground. Better efficiency may be acheived with centre loading. The longer the radiating wire the better too.

More Details

The antenna was fed by coaxial cable from the shack in the bedroom at the front of the house to the feed point at the base of the fence at the bottom of the back garden. The coaxial cable enters a small plastic box, screwed to the fence post, where it is terminated: The outer conductor of the coax is connected to the earth cable with a 'chock block' connecter, the earth cable going to a four foot long earth rod hammered into the ground near by. The centre conductor of the coax is connected to the antenna cable also using a 'choc block' connector.

The antenna wire runs vertically up the fence for about 1 metre to the loading coil which consists of 64 turns of the antenna wire wound around a piece of 4 inch diameter PVC pipe. About 32 turns a close wound and the other 32 turns space wound; The inductance, and therefore the point of resonance could be easily adjusted by altering the spacing of the windings. Once set at the required point of resonance the windings can be held in place with duck tape.

The antenna wire exits the coil at the top and passes through a pully secured to the top of the fence and then slopes upwards for about 10 metres to the fixing point at a convenient point on the house, in this case the eaves. The end of the wire is tied off to a plastic 'egg insulator'. The egg insulator is tied to a nylon halyard wich passes through a second pully at the fixing point. This allows the antenna wire to be quickly dropped for adjustment and then raised back into position.

The earth system should be as extensive as possible for better efficiency; e.g. earth stake and a number earth radials, as long as possible around the garden to provide a counterpoise.

Link:

Visit www.g7klj.com - the website of 160 metre entusiast Steve G7KLJ

OTHER THINGS

Antennas for HF

There are dozens, if not hundreds, of antenna designs from which to choose. All have their own proponents. Some are genuinely good while others might be considered as nothing more than glorified dummy loads! The key thing for me was to choose the most effective an antenna that could fit within the constrains of my small back garden and also one that would not be too ugly.

I decided that wire antennas, made from PVC covered stranded wire, would be least objectionable on visual grounds. After all they look like glorified washing lines and almost everyone has a washing line**!**

Knots to use when fixing Wire Antennas

It's important to use the correct knot for the job. I find that the Bowline is very useful for fixing end, egg and dog-bone insulators to the ends of the wire and/or ropes. The Round Turn & Two Hitches, Anchor Bend and Buntline Hitch knots are very good for tying a rope to a pole or a mast. A Double Sheet Bend can join two pieces of rope together - even if they are of unequal size. 'Animated Knots' will show you how to do them: http://www.animatedknots.com

The antenna or antennas really are the key to an effective amateur radio station. The most expensive radio will be of little value unless it is used with the best possible and most effective antenna; so I had to set about finding the best antennas that I could accommodate for HF and VHF work.

The dilemma facing most radio amateurs is that antennas for HF are often large and difficult to accommodate in modern small back gardens. Additionally there may be objections on the grounds of visual impact. Some people do

not regard antennas as the beautiful creations that radio enthusiasts do!

Cables and Feeders

As I have learned by experience and from the tutorials I have studied as part of the licensing exam process, a very important consideration concerning the antenna system is the loss incurred in the cable that connects the radio to the antenna. A loss of 3dB sounds like a small amount when you say it quickly, but that equates to only HALF of your transmitter power reaching the aerial! We'd soon complain if our new 100 watt transceiver only produced 50 watts - so why stand the chance of losing this much power in the feed line?

Starting off as an M3 licensee I could only use 10dBw (10 watts) power at the antenna termination, so if I had a feeder with a loss of 3dB I would have to run the transmitter at 20 Watts to get 10 watts to the aerial!

Coaxial Cables

For HF using a single band resonant antenna, a dipole for example, Mini 8 or even RG58 is probably fine since the SWR should be between 1:1 and 2:1. However if one was to consider using the antenna on non resonant frequencies the VSWR will be higher, maybe very much higher, and the consequential losses in coaxial cable will be greatly magnified and power losses very significant. I did not want to run such an inefficient station.

For this reason I chose to use low loss RG213 coaxial cable for my Inverted L since I may need to use it on bands other than the 40 metre and 80 metres that it is intended for and where the SWR may be 4:1 or 5:1. RG213 will help keep feedline losses to a minimum. No lossy RG58 on Mini8 for me! Westflex 103 would be even better, of course.

For VHF and UHF I now consider Westflex103 as the minimum standard of cable to use, it's half the loss of even RG213. Losses at VHF are much higher than HF and at UHF they are even higher, so Westflex 103 helps preserve as much of that precious transmitter power as possible.

See more about Coaxial Cable Losses here >

Balanced Feeders = Low Noise

It's difficult to feed a centre fed wire dipole with RG213 or Westflex 103, both cables are really too thick and heavy. RG58 or Mini 8 are lighter and therefore more suitable for suspended wire dipoles, but to match the unbalanced coaxial cable to the balanced dipole would need a 1:1 'choke balun' at its centre, as I have learned. However, as mentioned above, when attempting to use the dipole at non-resonant frequencies the VSWR will be higher and the losses in the coaxial cable will be very much larger too, and hence much less of the precious transmitter power will be actually radiated by the antenna. Not an ideal situation

I have learned that the only really sensible way to feed dipole type antennas, which are 'balanced', is to use a balanced feeder such as 300 ohm ribbon cable, 450 ohm ladder line or the best option, it seems, might be 75 ohm Twin Feeder. All such twin feeders are extremely low loss, much much lower than any coaxial cable, so low that it could almost be considered lossless by comparison. Of course nothing is lossless, but twin feeder is as near as you'll get, so that's how I will feed my dipoles from now on! See the note on Doublet antennas below.

Tony Nailer of Spectrum Communications notes that: "75 ohm twin feeder is lower loss than coax. It allows the aerial to be properly balanced and the very close spacing of the wires prevents pickup or radiation from the feeder. It does not need to be spaced off, unlike ribbon feeder. Use of twin feeder makes this aerial much lower noise than one fed with coax. Also importantly it generates less TVI !! Note that the [trapped dipole] aerial is generally 72 ohms, and will need to be used with an ATU with transistorised rigs which are unforgiving about SWR mismatches."

Spectrum Communications are now supplying a new design of top quality, very low loss, twin feeder. It is rated at 2kW at 100 ohms. It can be supplied by 100 metre reel or by the meter, or in various lengths with the ends expertly terminated and made off. I can confirm the superior quality of this product and its low noise properties.

Spectrum Communications also supply a very high quality, well made 1:1 Balun that is perfect for connecting the twin feeder to the unbalanced input of an A.T.U. of transceiver.

Doublet or Dipole (Horizontal or Sloper)

I have also experimented with a second HF antenna - the 'doublet' style antenna. I fed this with low loss twin feeder and cut it for the lowest frequency of operation, in my case 20 metres (14 MHz).

Some initial experiments have shown that it is very effective on 20 metres, better than my Inverted L - which is designed essentially for 80m and 40m.

In theory a doublet antenna, when fed by twin feeder (NOT coaxial cable) and matched at the transmitter end via a

1:1 balun and an ATU (or to use a more correct term, Antenna Matching Unit) at the transceiver should be able to work on all bands with a higher frequency than the band that it is cut for.

On other bands such as 17m (18 MHz), 15m (21 MHz), 12m (24 MHz) and 10m 28 MHz) the doublet showed generally lower VSWR than the Inverted L .... however (and here is a nice lesson) it is actually not quite as effective as the Inverted L! I think that size may matter here - the overall length of the Inverted L is much longer.

This short 14 MHz doublet is only about 10 metres in total length and was suspended at about 25 feet high at one end from the same fibreglass pole fixed at the apex of the roof and taken down to another 16 foot high wooden pole installed on the other side of the back garden in somewhat of a 'sloper' style.

Trapped Horizontal Dipole or Vertical Antenna for 20m / 10m

I also experimented with a trapped wire dipole cut to be resonant for 20 metres and 10 metres, again fed with twin feeder and matched at the radio end via a 1:1 balun and the ATU (AMU !).

I may also try an antenna for 20m / 15m and 10m in a Vertical 'ground plane' arrangement which should give a lower angle of radiation than a horizontal dipole - therefore better for longer distance DX.

At the moment I am using the 20m / 10m trapped dipole in a rather unorthodox arrangement. I have installed a fibreglass fishing pole, mounted vertically on a stake on one side of the garden. Most of the wire dipole is fixed to the vertical pole, but being as the dipole is somewhat longer than 7 metres, a portion of the wire runs away from the pole horizontally along a fence panel about 1.5 meters above ground level. It's vaguely L shaped, but mostly vertical which should help with the angle of radiation. It seems to work very well indeed - I like the mostly vertical idea.
The antenna can be seen on this page >

Other Dipoles:

Spectrum Communications can supply a full size W3DZZ style antenna with a 7MHz trap for use on 40m and 80m and usable on 20m, 15m and 10m. A half size version with a 14 MHz trap for use on 40m and 20 metres, plus 15m and 10m is also available. As a special order an even shorter version using a 28 MHz trap is available for 20 metres and 10 metres. http://www.spectrumcomms.co.uk/G2DYM.htm Al versions designed to be used with balanced line feeder - lince they are balanced aerials - for low noise and lowest loss.

PDF Document - The W3DZZ Antenna - http://www.users.icscotland.net/~len.paget/GM0ONX%20trap%20dipole.pdf (But rather than using coaxial cable with a 'choke balun' at the centre of the dipole, try using twin feeder with the Choke Balun at the radio end for less power loss!)

Links

Enamelled copper wire supply: http://www.esr.co.uk/electronics/cable-copper.htm

Loading coil calculators: http://www.k7mem.com/Electronic_Notebook/antennas/shortant.html

Ring Core Calculator: http://www.dl5swb.de/html/mini_ring_core_calculator.htm

Vertical Antenna For 50 MHz, 144 MHz and 430 MHz

Watson W-2000 on Telescopic Mast at the lowest position
more on this page

OTHER ANTENNAS

Our good friend in Australia Felix Scerri, VK4FUQ, uses Inverted V antennas but also highly recommends the Quad Loop style antenna for HF work. These are well worth investigating, and you can read more here: Antennas 3 see the antennas at the MØMTJ QTH here with many more antenna ideas on Antennas 4 and the Links Page here and here

Antennas 1 | Antennas 3 | Antennas 4 | Antennas 5 | Antennas 6 | Antennas 7

M0MTJ | Operating Conditions | Antennas / Aerials | /P Portable Operating | Accessories | Projects & Kits | Useful Information

Contact MØMTJ | Contact M6ORS | Links to Amateur Radio Sites | RSGB | QSL | The Amateur Radio Mini Site Map

WSPR Weak Signal Propagation Reporter

News, Developments, Events, Photographs and other 'Bits 'n' Bobs'

MDS975 Home

Feedback

MAIL

M0MTJ

Amateur Radio; Ham Radio; Radio; Transceivers; HF; VHF; UHF; Data Modes; Morse Code; RTTY; PSK31; SSTV; FSTV; Amtor; Sitor Antennas; Aerials; Cable; Coaxial Cable; Twin Lead; Masts; Poles; Propagation; Computer; PC; USB Computer Interface; Microphone Loudspeaker; Filters; Noise Reduction; DSP; Digital Signal Processing; Morse Key; SWR ; Inverted L; Inverted V; Dipole; Doublet.

"Everything should be made as simple as possible, but not simpler." - *Albert Einstein*

AERIALS (ANTENNAS) 4 - Notes and Queries

Antennas 1 | **Antennas 2** | **Antennas 3** | **Antennas 5** | **Antennas 6** | **Antennas 7**

Multi Band Aerial Options | Useful Aerial Rigging Accessories | Aerial Trimming Chart | Useful Knots | A few antenna related Links

As G4ILO notes: An antenna may have two of the attributes: Small; Efficient or Broadband (works over a wide frequency range without retuning) but never all three.

Marconi spins in his grave every time a ham buys an aerial instead of building it ! *(W1GFH)*

THE QUEST FOR MULTI - BAND OPERATION - In A Limited Space

The aerial is arguably the most important part of any station. No matter what transceiver is being used it is the aerial that is the last and most vital link in the chain and needs to be efficient and effective to radiate the signal to best best effect. Some amateurs are quite content to operate on one or two bands while others might want to be able to operate on many or even all of the amateur HF bands. When I gained my licence I definitely fell into the latter camp!

It seems, then, that the holy grail of many amateurs is the perfect multi-band aerial!

Luckily N4UJW has designed a new limited space 160m through to 70cm marvel antenna the plans of which can be found here:
http://www.hamuniverse.com/antwish.html

Having experimented with various types of antenna I am of the opinion that, perhaps along with many other amateurs, for simplicity a resonant dipole is the most efficient and effective of aerial. A resonant dipole it is only a single band aerial of course, but it is extremely cheap and very simple to make - and it's a very efficient radiator. So one could make a dipole for every band of interest and simply swap aerials to work different individual bands. Unfortunately the aerial described by N4UJW does not exist and compromises, such as lack of bandwidth or poor radiation efficiency, have to be made.

The principal of lowering a dipole cut for one band, removing it and hoisting another dipole cut for a different band in to place sounds pretty straightforward, but would the process become frustrating after a while. I think it could, so what about an antenna that will allow operation on several bands?

The Quest For A Multi - Band Aerial

Here is a collection of commercial and 'home brew' (DIY) antenna ideas that will allow multi-band operation, many of which could also be used in a location that offers limited space. Perhaps this only scratches the surface, but hopefully will provide a good starting point and fuel the mind in a quest for a good multi-band HF aerial. Do check out the manufacturer and supplier websites given on this page for lots more options and details.

Home Brew! It has been said that no radio amateur should ever buy an aerial - especially a wire aerial! Joe Tyburczy WB1GFH also comments about suitable antenna installing weather on his web pages:

"When you put up your antenna is also crucial. I must mention here the importance of what many early hams called "antenna weather". That is, snow, sleet, freezing rain, or combination of all the above. It has been proven time and time again that any antenna installed in conditions better than abysmal will not function worth a darn. Or, put another way, it takes bad weather to put up a decent antenna. Dark and cold New England winter days are ideal for this activity. Any antenna erected on such a day will inevitably produce miracles." Joe Tyburczy WB1GFH

Most of what is available commercially could be 'home-brewed' if one has the time and a few suitable mechanical skills.

It's worth bearing in mind that Joe Tyburczy's $4.00 Special may well be more effective than a commercial antenna costing $400.00. Perhaps the equally inexpensive Zepp Antenna could produce far greater Value For Money than shelling out £$hundreds on a commercial antenna?

I give no particular recommendation here, but a good rule of thumb is not to believe the marketing hype of any commercial company supplying antennas.

A good place to start is, I think, the classic All Band Doublet Antenna, which is mentioned several times below. Plenty of links are also provide further down this page.

As important as not believing any of the marketing hype is remembering the words of the Star Ship Enterprise's Chief Engineer Mongomery Scott; (paraphrasing) *You cannae change the laws of physics!* - Size matters. A coil loaded 5 foot long aerial probably won't be that much good on the H.F. bands. Indeed, a a 5 meter long antenna may be perfect for the 10 metre band but it won't be a great antenna on 20m, and certainly even less effective on 40m and 80m

So, before falling for all the marketing hyperbole its wise to read up on a little antenna theory and do some lengthy research into the antennas being considered before making an expensive decision.

Below are a few clues and ideas listed in no particular order - some of the antennas will be great while some of the commercial designs shown below may promise great things but fail to meet high expectations.

There is no "miracle antenna". If one understands the theory and the compromises made with shortened, under-sized, multi-band (and often very expensive) antennas there may not be so much disappointment. However most will be compromised in one way or another, so if one is happy to live with those compromises, understand what they mean, and are happy to have a lighter bank balance then that's fine!

Low SWR across all the bands does not indicate a good antenna. My dummy load has very low SWR across all the bands but it is most certainly not a good antenna!

Someone telling you that the antenna that they're using is great and that they've worked the world doesn't mean it really is a good antenna - it's just 'hearsay'. One could quite possibly work around the globe on a coat hanger in the right conditions - it doesn't suddenly make a coat hanger the great antenna that should be widely heralded!

The best way to learn about antennas is to go out and make some - well actually go out and make many antennas.

Here are a few ideas. Some that are easily 'home brewed' and some commercial ideas that could be adapted to 'home brewing'. I don't have any particular recommendation, but I hope that this list will provide some good food for thought. (Some of the commercial antennas may be okay, some may be awful).

Remember; ***Marconi spins in his grave every time a radio amateur buys an aerial instead of building it !***

The Doublet Antenna - the classic all band / multi-band Aerial

The Doublet Antenna is my favourite Multi-Band aerial. The main benefits of a Doublet Antenna are that it can be

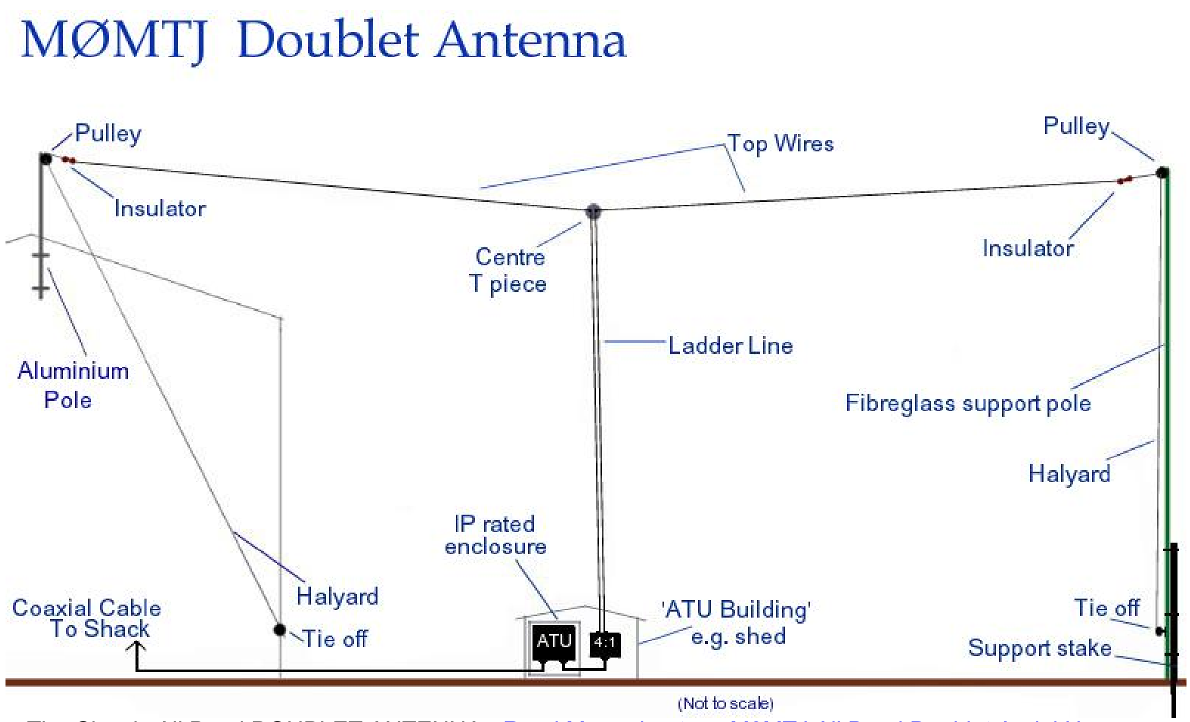
used on whatever frequency it is cut for, and higher frequencies. Usefully, there can be some useful gain on higher frequencies, although there will be some petal shaped lobes on the higher frequency bands.

In fact my 20 meter long Doublet for the 40meter band to the 6 metre band also works quite well on 80 meters! Not only a very good starter antenna for those looking to work as many bands as possible, but also an aerial that would be useful and efficient for years and years to come.

Ladder line or open wire feeder must be used (NOT coaxial cable). Ladder Line or open wire ensures low loss at High Frequencies so that as much of your precious transmitter power as possible will be radiated. Likewise receive efficiency should be maximized. Assuming that the aerial is successfully balanced, the feeder should not radiate, even when there is (inevitably) high SWR

High SWR is not an especially bad thing and will not reduce the aerial's performance, but note that high SWR on the balanced feeder does increase feeder loss compared to a when matched - but the losses will be a lot less significant then if coaxial cable were to be used. This ensures that efficiency should be better so that all the power that reaches the antenna wires will be radiated - save for any losses in the antenna tuning unit (AMU) or the balanced feeder cable.

Remember: Ladder Line = Lower Loss - Read more about my M0MTJ Doublet Antenna HERE >> and more notes on this page here >>



The Classic All Band DOUBLET ANTENNA - Read More about my M0MTJ All Band Doublet Aerial Here >>>

The G5RV and more about Doublets & Dipoles

The G5RV - (Even Louis Varney himself said that a Doublet would be better!)

Why the G5RV continues to remain popular is a mystery. The 'legendary' name, perhaps? That it can be 'thrown up' without too much thought? The fact that it' cheap and cheerful? Well, cheap anyway. There has been much written about the G5RV and the overall conclusion is that it's not a very good multi-band antenna. Certainly it will work quite well on, perhaps, a couple of bands, but there are better alternatives, especially when one considers the wide availability of remote automatic antenna matching units (remote auto 'a.t.u.'s) that will greatly assist in minimizing antenna feeder losses.

Perhaps the best thing that can be done with a G5RV is cut off the coax, re-size the top wires and turn it into a true Doublet Antenna - or, better than that, don't buy a G5RV in the first place and simply make (home brew) a true All Band HF Balanced Doublet Antenna.

The G5RV and its derivatives such as the Western HF-10 and the ZS6BKW are a bodge. In fact, Louis Varney G5VA himseld stated that a much better alternative to any of these 'G5RV' designs is to run the open-wire line from the center of a dipole all the way to a balanced antenna tuner!! This aerial arrangement will work on ANY band from 80 metres through to 10 meters.

The G5RV is, therefore, not the most efficient aerial and, as users report, may not always be the easiest to use, but because it is coax fed, it remains an ever popular choice because it's easy to feed the coax cable from the antenna's location back to the shack. Unfortunately this easy (lazy?) approach means lots of loss due to high SWR on the coaxial cable.

One may say, Oh well, there's perhaps only 2 or 3 S points in it. (Cough!). A difference of 3 S points is the difference between radiating 100 watts or only radiating 1.6 watts. Um, - I'm sure we'd soon complain if our shiny, new 100 watt transceiver only produced 1.6 watts!!

QRP and lower power portable operators should be especially keen to minimize antenna system losses so that as much power as possible is radiated. Losing 3 S points from a 5 watt FT-817 results in only 0.08 watts. QRP operators may likely favour resonant, single band antennas for greatest efficiency.

Coaxial Cable is only 'low loss' when the antenna impedance is similar to the cable's designed impedance of 50 Ohms, or near 1:1 SWR (or at least less than 2:1). Coax cable is therefore fine for a Dipole antenna that is designed to be resonant on one band of choice, which will have a reasonably low SWR across that band, but coax' is entirely unsuitable when one wants to use the aerial on several bands. The G5RV will be used an multiple bands and will therefore present widely varying impedance values (and SWR) depending on the band of operation and so the power losses will be significant.

Note: The antenna's true impedance (SWR) must be measured at the antenna's feed point (i.e outside and up in the air) not at the radio end of the cable, in the shack, where the coaxial cable's losses will mask the true SWR reading. Unfortunately 50 Ohms, or a near 1:1 match, will not be encountered on any band on a G5RV. The best band will be 20 metres at typically 2:1 (100 Ohms), but on any other band the impedance will be very much higher. One might expect rersults like these: 80 metres 3:1 to 5:1, 40 meters 5:1, 30 metres 20:1 or more, 17 metres 15:1 or more, 15 metres 6:1 to 12:1, 12 meters 3:1, 10 meters 10:1 to 20:1.

1000 Ohms into 50 Ohm coaxial cable will result in a massive dumping of your power - lost as heat in the coaxial cable instead of being radiated as a useful signal. However, high SWR is not in itself a bad thing - it's just that the correct type of feeder and impedance transformation method needs to be used. The *incorrect* feeder is coaxial cable - the correct type of feeder is balanced Line or Ladder Line feeder. This can be the typical slotted 300 Ohm type or the 450 Ohm 'window line' which are commercially available. Even better, make your own open wire, balanced line feeder. Spacers can be bought commercially or 'home brewed'. The spacing for this parallel line should be about 2 to 3 inches (50 to 80 mm) - the width of the spacing is not particularly critical, but whatever width is chosen should be maintained as accurately as possible along the length of the feeder - i.e. it should be parallel.

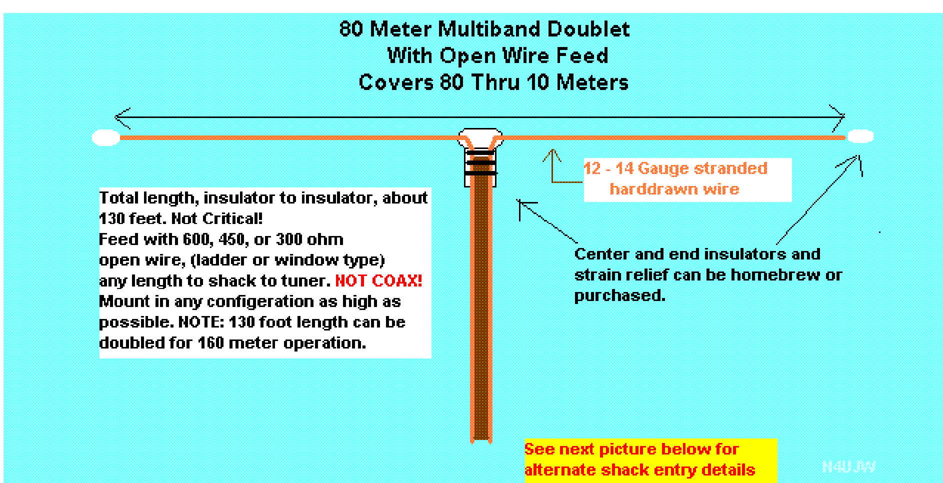
The Doublet can take more time and effort to tune, prune and adjust. It will also need a good antenna matching unit (so-called "ATU") and low loss balun, but the reward will be more effective performance due to the much reduced loss in the balanced line feeder system.

Doublet Aerials - a better alternative to a G5RV

Check out the The classic All Band Doublet and the NorCal Doublet for very simple, effective and versatile antennas for multi band operation:

The ALL BAND Doublet Antenna

This could very well be the first antenna that one should try in order to get on at least one band very efficiently but also several other bands with the use of a good ATU.



All Band Doublet - http://www.hamuniverse.com
See My All Band Doublet Antenna here

The all band Doublet antenna is nothing more than a 1/2 wave dipole cut for your lowest operating frequency and fed with twin lead, ladder line, open wire, etc to a tuner that will accept a balanced line connection. IT MUST NOT BE FED WITH COAXIAL CABLE !

It can be designed for use from 160 through to 10 meters very easily using the standard 1/2 wave dipole formula:

468/freq MHz = total length (ft)
The exact length is not critical!

If there is insufficient room for a lower frequency version (160m or 80m), then the Doublet can be designed to the shorter wavelength of the 40 metre band and used up to the 10 metre band. (Do not attempt to operate on a lower frequency than 7 MHz in that case since this could damage the a.t.u.) It may be possible to connect the ends together and tune it against earth - if you have a good enough earth - and use lower frequency bands. For best results a doublet should be mounted as high as possible (as with many aerials) and can be erected as a flat top or inverted V.

A Doublet Antenna needs a good antenna matching unit with a wide impedance matching range (obviously not the one in the radio!). Preferably this should be a balanced antenna matching unit, but an unbalanced matching unit can also be used together with a good low loss current / Guanella balun, such as the extremely high quality items available from G-Whip Antennas. I use a 4:1 G-Whip guanella current balun with my Doublet, but many users recommend using a 1:1 ratio current balun - again, this is a case for individual experimentation.

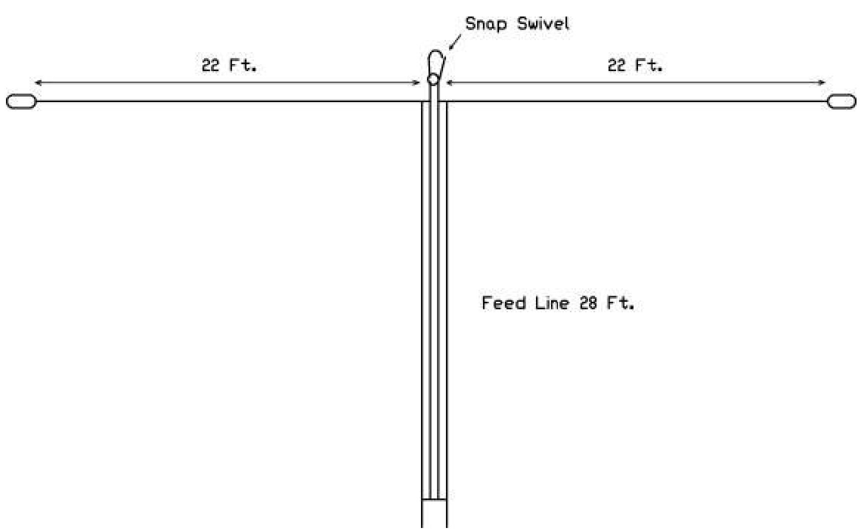
A more detailed description of the Doublet Antenna can be found here >>

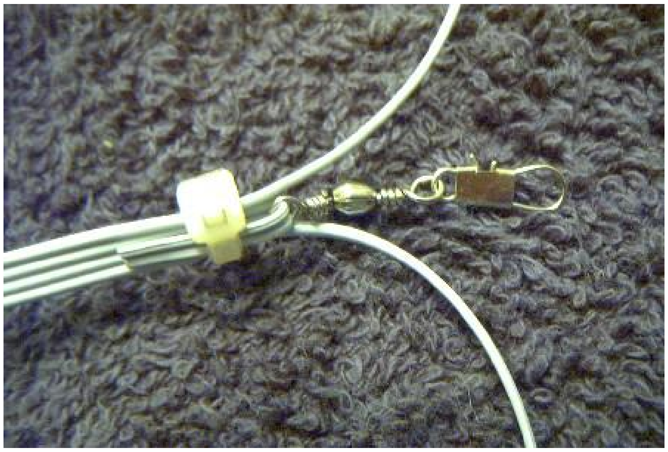
External Links

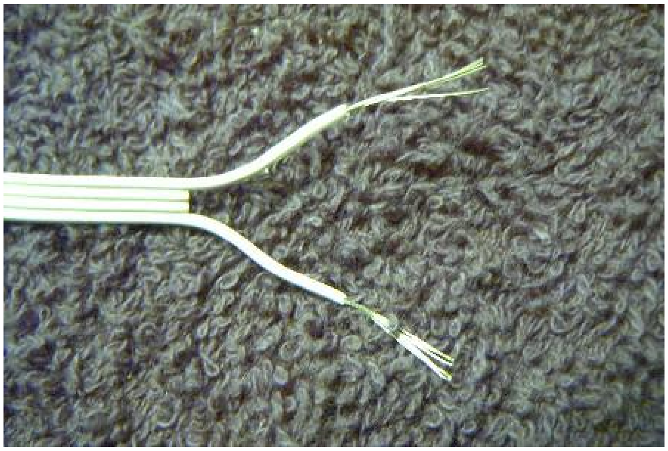
The All Band HF Doublet can also be found on Ham Universe: http://www.hamuniverse.com/hfdoublet.html

Introducing The All Band Doublet by the late L.B. Cebik W4RNL: http://www.cebik.com/content/edu/edu6.html
N.B. Create a free account at http://www.cebik.com

The Norcal Doublet







The Norcal Doublet Antenna: http://www.norcalqrp.org/norcaldoublet.htm

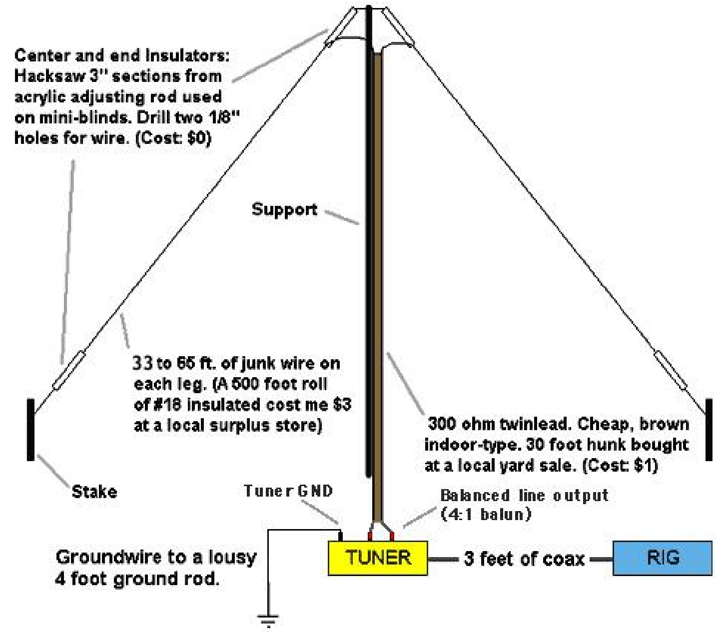
The Norcal Doublet is a simple antenna that is 44 feet (13.4 metres) long, 22 feet (6.7 metres) per side. The Norcal pages report "...that the antenna would have basically the same radiation patterns on all bands from 40 - 10 meters. This would be very handy to have for field operation..... You will need the following materials: 50 feet of 4 core stranded computer cable; 1 #0 Fishing Swivel; 1 Cable tie; 2 pieces of fishing cord."

The antenna can be hung from trees or cheap telescopic 'roach' / Sota poles. Doubling the size would allow operation on 80 metres and even 160 metres by shorting the twin feed together at the transmitter end and feeding it against a good earth as a 'Marconi' type antenna.

An effective multi-band "4 Dollar Special" by Joe Tyburcy - W1GFH (An Inverted Vee Doublet Antenna - super cheap - super effective - multi-band)

Joe Tyburczy, W1GFH provides some sensible insight and advice, he writes: *"I am a big fan of "balanced line" (twin lead, open wire line, etc.) vs. coax. By using balanced line and a tuner you can have one, single-element antenna that works well on all bands. You can't do that as easily with coax. The basic "W1GFH $4 SPECIAL" shown below is a variation on the type of versatile skyhook I've been using for years......Now at this point, some of you may be looking at the diagram and muttering, "Jeez Joe, that's just a dipole fed with twin lead and used with a tuner". Well of course it is. Virtually all antennas are "di-poles" (i.e. "two sides") in some form or another. This one just happens to be made from low-cost materials......I won't go into the theory here, but trust me: balanced feed line, properly used, does not "leak" RF and is less lossy than coax. I've tried the commercial 450-ohm ladder line, but prefer 300-ohm TV twin lead, and the cheaper the better. Radio Shack TV twin lead is ideal. Home Depot has some good stuff, too. Forget all the obsessive junk about standing waves, impedance and velocity factor. What you really need to concentrate on is getting an interesting set of antenna insulators."*

Read Joe's excellent article in its entirety here: http://www.qsl.net/wb1gfh/antenna.html



4 Dollar Special by W1GFH
http://www.qsl.net/wb1gfh/antenna.html

Inverted L - 80 metres to 10 metres

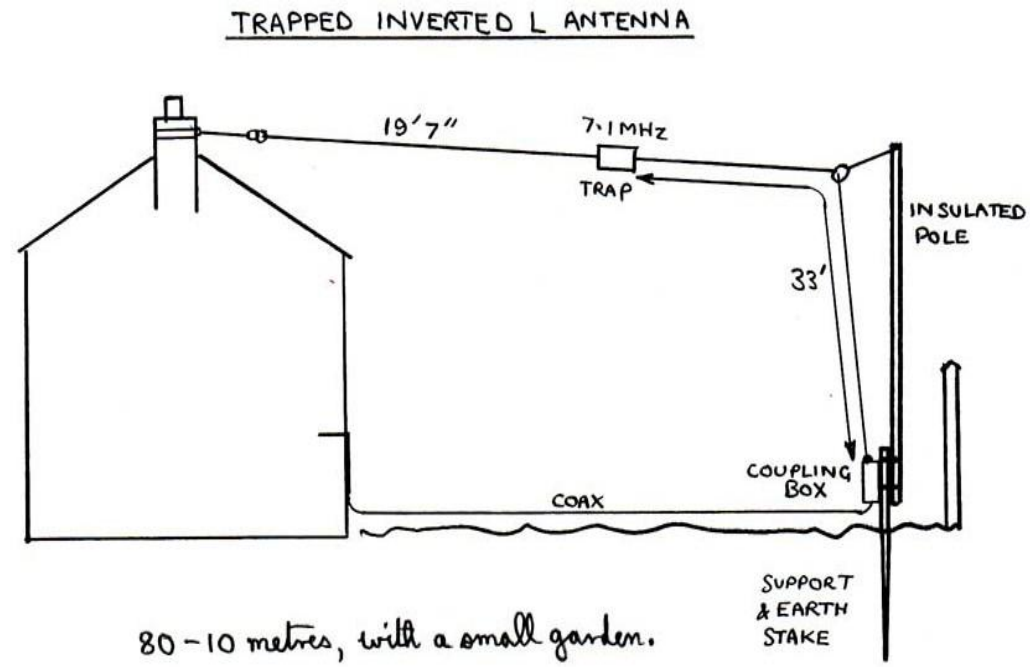
A typical Inverted L antenna will be trapped for 40m/80m using a 7.1 MHz trap. It is essentially one half of a W3DZZ dipole so can be accommodated very much more easily into a small plot or garden - especially as part of the antenna is running vertically up a wooden or fibreglass (non conductive) pole. This should allow it to be fitted into quite a small garden such as mine. It's a very useful antenna in this respect, and because there is a good length of wire in the air, it radiates quite well.

The Inverted L is also a very effective aerial because it has the benefit of both vertical and horizontal radiation. While Inverted L's might make good TX aerials, like ground mounted vertical aerials they do have the potential to be a little noisy on RX. This will depend upon local circumstances and noise sources. However the fact that the feed point will generally at the bottom of the garden, well away from the house may help to keep QRM to a minimum.

The Inverted L is extremely easy to 'home brew'. Spectrum Communications can also supply the complete aerial as shown below. It should give excellent performance on 80m and 40 metres, with 20 metres also being good but also allowing use on 15m and 10m and possibly one or two of the WARC bands.

If you fancy home-brewing the complete antenna, except for the 7 MHz trap, traps are available to buy commercially from suppliers such as Spectrum Communications and Sotabeams who supply very neat and lightweight devices,

Use a Remote Automatic Antenna Coupler : The use of a good Automatic Antenna Coupler, such as the CG Antennas CG-3000, at the feed-point with a simple inverted L wire will provide a very good Multi-Band aerial that could be used on all bands between 160m and 10m and should be very simple to deploy.

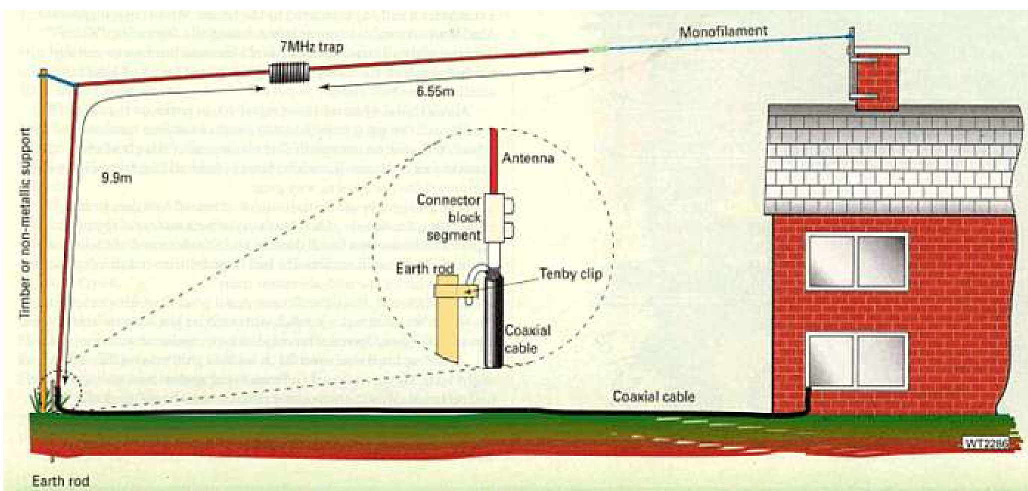


Spectrum Communications Inverted L - benefits from both vertical and horizontal radiation
http://www.spectrumcomms.co.uk

More about Inverted L Aerials:

The Inverted L for 40m/80m is shown below is essentially one half of a W3DZZ dipole fed against ground using one 7.1 MHz trap. It's a very compact antenna and is simple to construct. It is most efficient, of course, on 80 metres and 40 metres, but can also be used, with an a.t.u., on 20m, 15m and 10m.

Find out how to make one here: http://www.users.icscotland.net/~len.paget/5%20band%20Inverted%20L.pdf

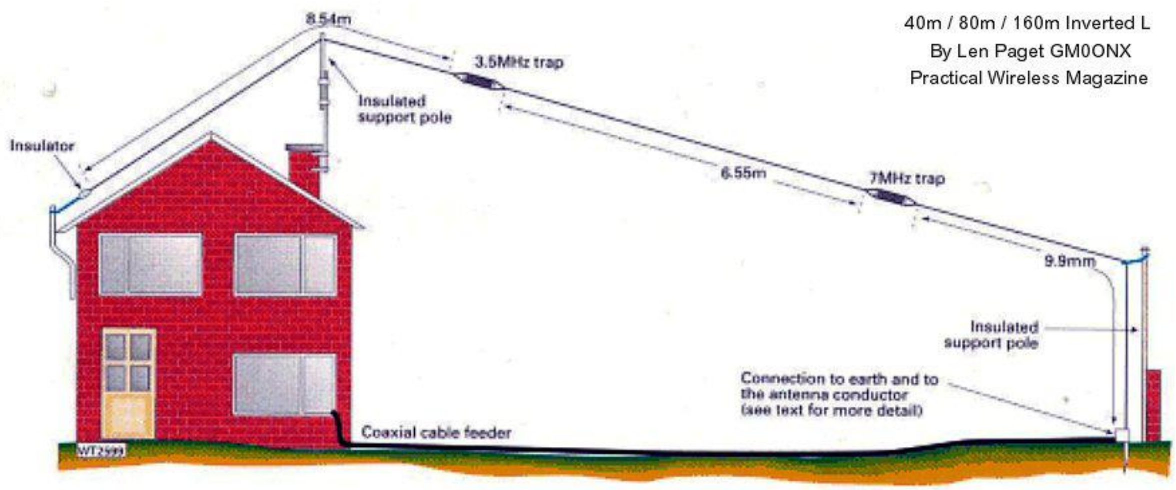


The basic layout of the Inverted L Antenna by Len Paget GM0ONX (Practical Wireless)

Adding 160m / Top Band to an Inverted L

The 160 metre Top Band can be added to this aerial by connecting a 3.5 MHz trap at the end of the 80 metre wire (where to monofilament joins the 6.55m section of wire below) with another length of wire on the other side, increasing the overall length of the antenna.

Find out how to do it here: http://www.users.icscotland.net/~len.paget/Inverted%20L%20adding%20top%20band.pdf

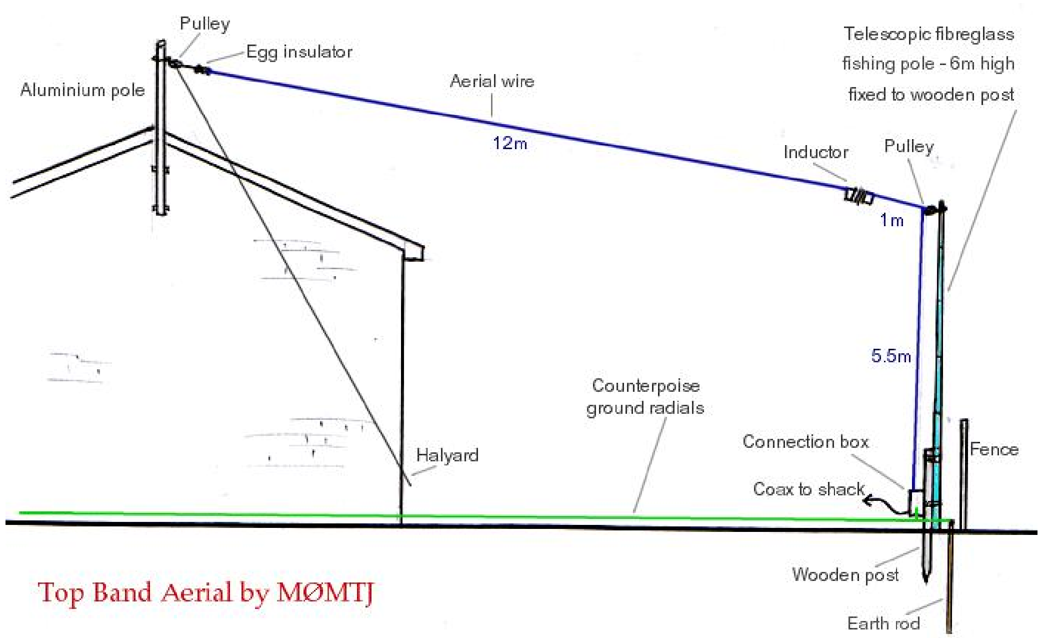


Adding Top Band to an Inverted L by Len Paget GM0ONX (Practical Wireless magazine)

160m Top Band 'Inverted L' Wire Antenna

At the time of writing I am using a 40m/80m Inverted L aerial and in an attempt to get on Top Band I have also been experimenting with a shortened 160m antenna in an inverted L configuration that uses a wire about 19 metres long - about half the size of a full size inverted L for 160 Metres.

A Top Band aerial of this type also needs a very good ground / counterpoise and can suffer the disadvantage, like ground mounted vertical aerials, of being rather noisy on RX . The drawing below shows the general idea. Read more here >



General layout of Top Band Aerial with fibreglass pole retracted to a height of 2 metres
Wire lengths are approximate: Inductor 5cm dia with approx 40 turns of enamelled copper wire

Full Wave Loops and Delta Loops - An easy to install and effective antenna for multi band operation

Easy and low visual impact - a full wave loop: With a larger garden a full wave loop could be easily accommodated horizontally without the neighbours even noticing. A garden with a perimeter of 40 metres would

easily accommodate a full wave loop for the 40 metre band and would work up to 10 metres or even 6 metres with an 'ATU'. A garden with a perimeter of 80 meters would accommodate a full wave loop for the 80 metre band and would work up to 10 metres.

Small Loop for 20 metres to 10 metres: A loop for 20 metres or 17 meters is relatively compact and could easily be installed in small 'postage stamp' sized gardens. A loop antenna could be triangular, square (Quad) or circular, but a square loop (and indeed a circular loop) would need more supporting points than a delta (triangular) loop, so a Delta loop is likely to be the easier option.

The loop is really a single band antenna cut for one wavelength on the band of interest, however it can also work quite well as a cheap and easy to install multi-band H.F. aerial. A loop consisting of a 17 metre length of thin antenna wire, for example, will work well on 17 metres but may also give 15m, 12m and 10m with an ATU. My own loop is made from an 16 metre length of wire, tuned for the 17m band, but can work on higher bands. A 40 metre loop will be considerably larger, but it might still possible to accommodate in many fairly compact gardens. Performance will depend on height and orientation.

Feeding the loop at the top or bottom will give horizontal polarisation, while placing the feed point on the side will give vertical polarisation. The apex can be at the top or the bottom, but performance should be better with the apex at the bottom with the flat wire across the top - however for ease it may be more convenient to support a Delta Loop on a single pole, meaning that the apex would be at the top.

Ideally a loop should be fed with balanced line back to the shack, connected to a balanced line ATU or other ATU via a 4:1 balun. Alternatively use a 4:1 balun at the antenna end and run 50 ohm coax back to the ATU / txvr - though losses will be greater doing it by this method if the coaxial cable is quite long.

If one can install a separate antenna for the lower frequency bands of say 160m, 80m and 40m, then a Loop Antenna could be a good partner to allow operation on the higher bands of 20 metres to 10 meters or even 6 metres.

A loop should be really very easy to install using a single support pole and very cheap too! All that's needed is the supporting pole, some cheap wire, a 4:1 balun which can be 'home brewed' and some thin cord and insulators which should not be an eyesore either.

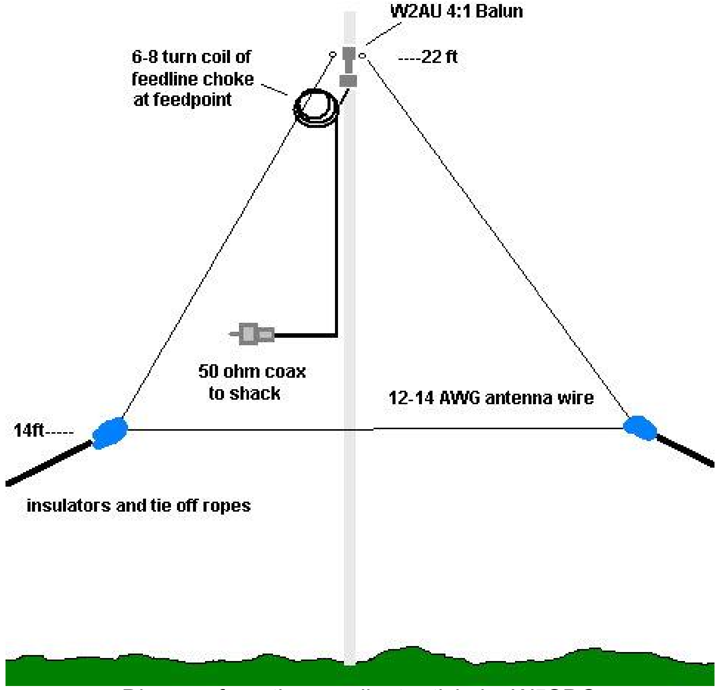
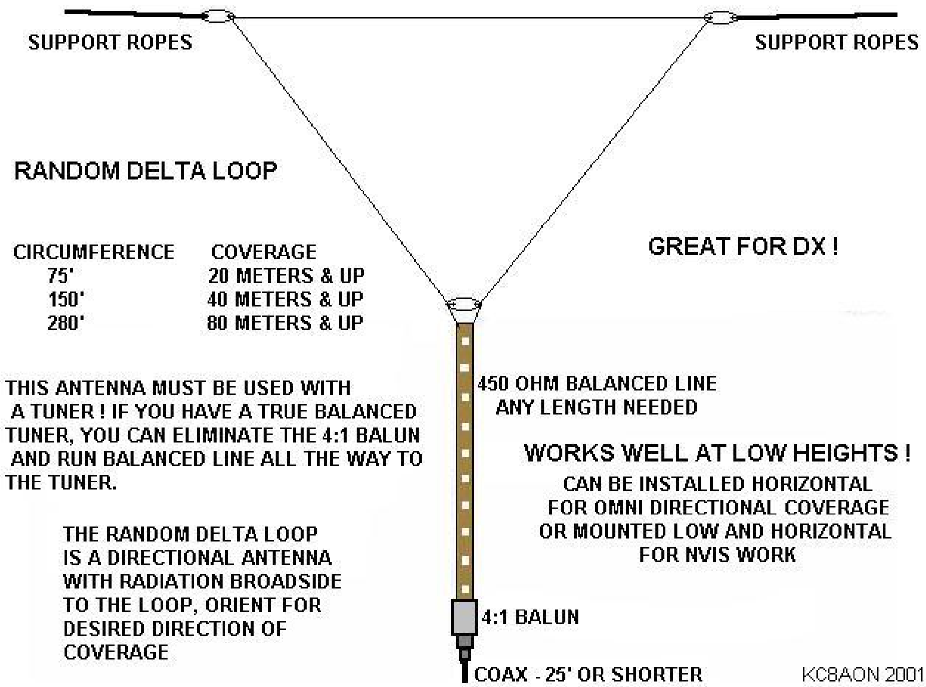


Diagram from the excellent article by W5SDC
http://w5sdc.net/delta_loop_for_hf.htm

Band	Length of antenna wire at mid band in metres
10	10.617
12	12.282
15	14.432
17	16.90

20	21.502
30	29.622
40	42.842
80	82.234
160	161.223

Delta or Quad Loop Antenna - An ideal multi band antenna solution?



A Multi Band Wire DX Loop Antenna by KC8AON
http://www.i1wqrlinkradio.com/antype/ch10/chiave1827.htm

Delta Loop by Arthur M0PLK (SQ2PLK)
Details at http://pdxa.one.pl/articles.php?article_id=17
Available at http://ham-radio.urbasket.eu and http://www.vpa-systems.pl/

Using fibreglass fishing poles (Sota Poles) two 7 metre long poles can be erected in an inverted V shape and used to support a 20 metre delta loop which will be usable on 20m to 10m and also adaptable for use on the 40 metre band.

The two aerial wires used are connected directly to a 4:1 balun which is, in turn, connected to an ATU such as the Z-11 Pro or Z-100 via coaxial cable. See this page which shows the W6ZO delta loop to get for the general idea of what will be achieved. The finished aerial will be very much like the commercially available ProAntennas DMV-Pro.

W6ZO Delta Loop - fed with 4:1 Balun - 40m to 10m
http://www.fros.com/KI0GU/w6zodelta.htm

The Loop Antenna. Ideal - cheap, easy, multi-band, simples! -
Lots of links to other Loop Antenna information on the links page here

Omni Directional Multi-Band Horizontally Polarized Delta Loop

If all that can be erected is a single pole, masts or telescopic pole, here is an option that will provide a horizontally polarized signal on 20 / 17 / 15 / 12 / 10 metres - the Sandpiper Aerial Technology GM3 (designed by GM3VLB). A similar idea, providing omni-directional horizontally polarized signals, is the G3TPW Cobwebb Antenna from Steve Webb.

These look like good ideas, though I have yet to make one to test.

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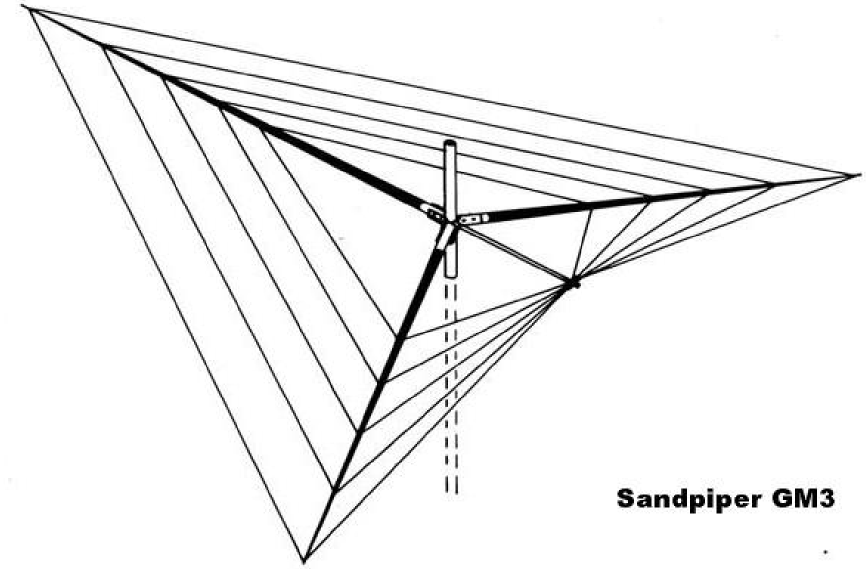


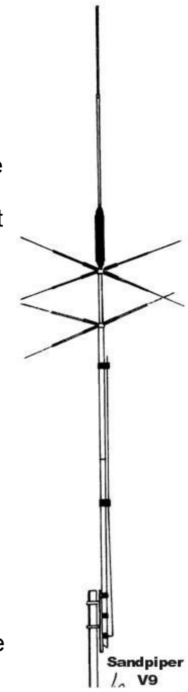
Sandpiper GM3VLB Antenna
http://www.sandpiperaerials.co.uk/

G3TPW Cobwebb Antenna from Steve Webb - photo by G3TXQ
http://www.g3tpw.co.uk http://www.karinya.net/g3txq

Resonant Vertical Antennas

Low SWR: Having a low v.s.w.r. across the whole of HF may seem, at first glance, to be a good thing - but my dummy load has a very low v.s.w.r. from HF to UHF, it does not make it a good antenna! As far as aerial systems are concerned, having a low v.s.w.r. across the whole of HF is probably not the best way to judge an antenna - a wide band low v.s.w.r. could indicate a fault with the aerial or feeder system - or just that lossy matching transformer that is gently heated up by the power applied from the transmitter!

A low v.s.w.r. is a good thing in a resonant antenna. It will help demonstrate the antenna's point of resonance - but the v.s.w.r. will rise either side of resonance. So:



The next commercial option is an antenna that is truly resonant on a number, but perhaps not all, bands. The Hustler and Butternut varieties are very well known and offer well reported good performance.

Some vertical antennas use traps to achieve multi-band performance and as such are essentially one half of a trap dipole, fed against ground. A consideration is that the traps themselves, particularly if multiple traps are used, will introduce losses to the antenna system. It should also be noted as an additional consequence of using traps on a ground mounted vertical antenna, is that the highest frequency element will inevitably be positioned at the lowest position on the aerial - not a good position to be, especially for local ground wave radiation where signals will more easily be screened by local structures. Ground conductivity also needs to be good for verticals to operate efficiently.

The Hustler 4-BTV, 5-BTV & 6-BTV aerials are examples of multi-band verticals that use traps; many amateurs report great success with Hustler aerials - and it is very low profile too, indeed an amateur friend of mine uses a Hustler with great success and has even modified an additional top resonator so that the aerial can be used on 160 metres..

Other manufacturers of resonant vertical antennas, using varying design methods, include GAP, Cushcraft, Diamond, HyGain, and the well known British names Moonraker and Sandpiper.

Advisory: These are perhaps a good idea for limited space situations, but the shorter versions will not work well on the lower HF bands. A 6 metre tall antenna cannot possibly work terribly well on 40m or 80m, but may work well on the 20 metre band and above. However one could easily 'home brew' an equally effective antenna for a fraction of the cost of a commercial antenna.

Sandpiper Aerials

Sandpiper Aerial Technology offer an enormous range of amateur radio antennas from HF to UHF. For HF working Sandpiper offer numerous options including simple multi band resonant antennas supported on fibreglass telescopic poles using either changeable or plug-in coils for different bands to the famous V range and shorter and more compact MV range and the Portable MV antenna on its own tripod base. The V and MV ranges use a rather innovative design, seen above right. The V and MV antennas are available in versions that cover all the HF bands - or as cheaper versions that just cover the particular bands of interest. http://www.sandpiperaerials.co.uk/

Vertical antennas will be quite short when compared to the wavelengths of some of the longer wavelength bands (particularly 40m, 80m and 160m) and so will not radiate as efficiently as a full size resonant aerial. The bandwidth will also be quite narrow. Setting up a multi band antenna to be resonant at the required portion of each band can sometimes be a little time consuming, but for the convenience it might be a price worth paying. A vertical antenna will generally have a low angle of radiation which is a good thing for long distance DX but verticals can be very noisy on RX compared to a balanced dipole and as previously alluded to, radiation efficiency will be very low when compared to a full size single band resonant antenna. Attractive options?

Alternatives: My favourite way of experimenting with aerials is using a 10 metre long fibreglass telescopic fishing pole as the support. These fibreglass poles are lightweight and easy to carry, put up and take down, ideal for supporting lightweight v.h.f. and u.h.f. yagis, wire dipoles and doublets and also for supporting vertical wire aerials.

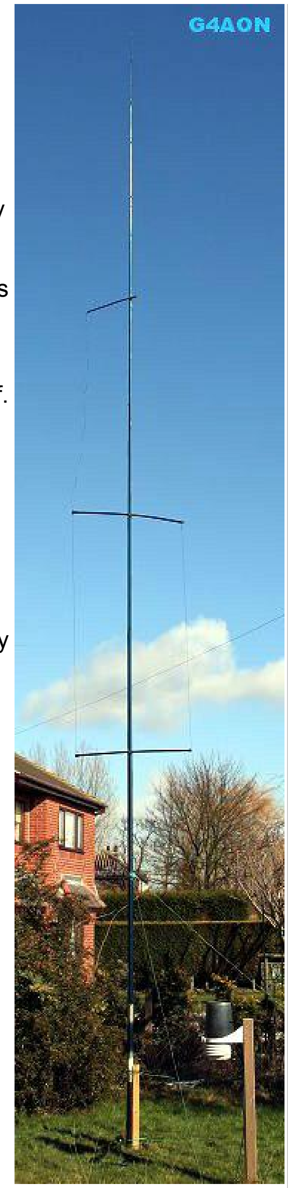
The telescopic pole must be made from fibreglass, not carbon fibre which is electrically conductive.

One great design is by Dave G4AON who writes on his web page: "There seems to be a myth among many newly licensed radio amateurs that an antenna works better if it costs a lot of money..... The antenna shown here costs around one tenth the price of a commercial vertical, yet it will perform as well as (and in many cases better than) a trapped vertical antenna. This antenna is based on a 10 Metre long fibreglass fishing pole.....the poles will collapse inside the sections unless each joint is secured with PVC tape, for more permanent installations glue could be used.

...The wire lengths are calculated from the formula L = 234/F, where F is the frequency in MHz and L is the wire length in feet. These lengths work out to around 33' 3", 23' 2" and 16' 7" for the 7, 10 and 14 MHz bands. The lengths for 7 and 10 MHz were more or less correct, however probably due to interaction between the wires the 14 MHz wire needed lengthening by around 4" for minimum SWR. Wire size is not critical, but it is probably better to avoid the thinnest "hookup" wire. Note, ground conductivity/loss and elevated/buried radials make a significant impact on both the performance and tuning of a ground mounted vertical. In the case of buried radials the vertical may resonate significantly lower in frequency than expected."

The antenna shown on the right is made for triple band operation on 7 MHz, 10 MHz and 14 MHz by the use of parallel wires, but an aerial based on a fibreglass pole could be single, dual, triple or even - at a push - quadruple band.

The more bands included the more difficult it will be able to trim to tune for resonance (as with a fan dipole) so to keep interaction to a minimum the wires should be quite well spaced. Like all quarter wave verticals aerials a good ground plane will be needed.



See G4AON's excellent full article here: http://www.qsl.net/g4aon/vertical/

Horizontal Resonant Wire Aerials

The great advantage of a vertical antenna is that they have a very small footprint, i.e. they can be installed in the corner of many small plots and gardens. True resonant verticals can properly cover many, if not all, the HF bands. However to be reasonably effective a vertical needs a very good ground and also must be quite tall, in the order of 6 to 9 meters in many cases (about 19 to 30 feet). This may cause objections from the XYL. Another disadvantage might be that a vertical has little near vertical incidence skywave radiation (NVIS), a consideration for the lower HF bands, so after the local ground wave coverage there will be little or no signal until after about 500 miles, not good for inter G working. (ref. G8JNJ) - So try some Dipole Antennas:

Dipole Antennas

The dipole antenna is possibly the simplest and cheapest antenna to make. It it cut for single band operation where it should make a very efficient radiator. The simple wire dipole should be quite discrete, though not entirely invisible, but should not raise too many objections from the XYL or neighbours.

For some dipole ideas see this page:
http://www.qsl.net/ta1dx/amator/practical_dipole_antenna.htm

How to make a basic dipole by Marshall N1FN : http://www.morsex.com/dipole/index.htm

Also see this detailed and useful page: http://www.dxzone.com/cgi-bin/dir/jump2.cgi?ID=7499

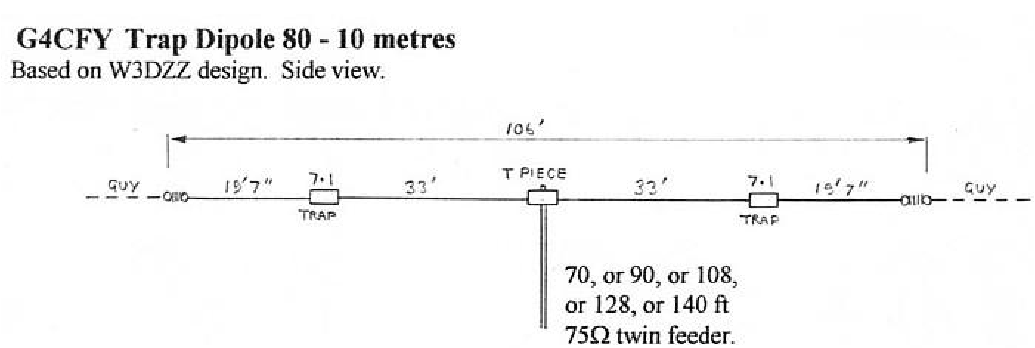
Calculator:
http://www.sean1226.pwp.blueyonder.co.uk/design_your_own_antennas%201.htm

TRAP Dipoles:

The next type of antenna to consider might, then, be a horizontal or sloping wire antenna. Perhaps the most familiar multi band wire aerial is the trap dipole. The traps, in simplest terms, divide a wire dipole into two or more resonant sections so that two or more bands can be covered.

As far as commercial options go then there are quite a number. Tony Nailer of Spectrum Communications produces a great deal of useful equipment and accessories including some well designed and well made trapped dipole aerials based on the very effective W3DZZ design. In particular the Full Size G4CFY resonant on 80m and 40m and also allowing operation on 20m, 15m and 10m, also the Half Size G4CFY resonant on 40m and 20m and additionally allowing operation on 15m and 10m.

Visit http://www.spectrumcomms.co.uk/G2DYM.htm for more information.



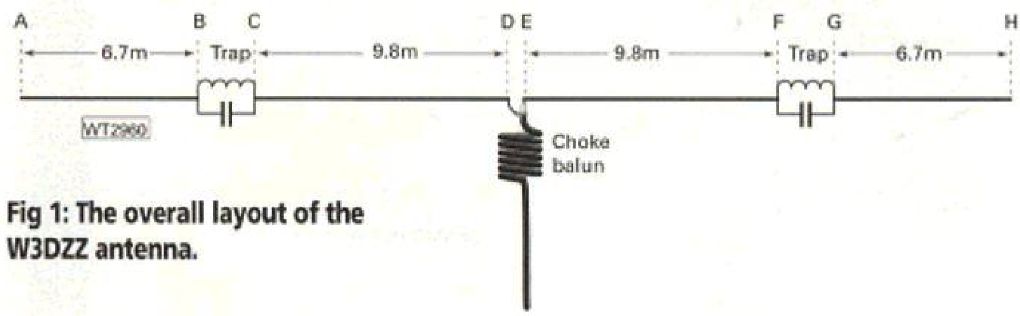
Spectrum Communications G4CFY Trapped Dipole
http://www.spectrumcomms.co.uk

Spectrum Communications G4CFY Trapped Dipole
http://www.spectrumcomms.co.uk

More about Coaxial Trapped Dipoles

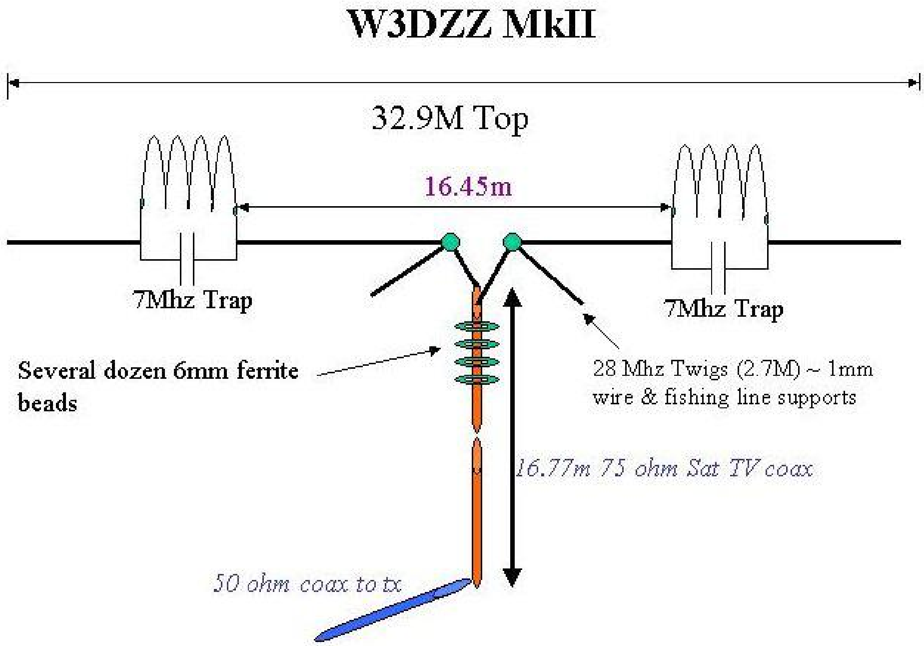
A trapped dipole for 40m and 80m offers the advantage of being somewhat shorter than a full size single band 80m resonant dipole plus it offers 40m as a resonant band plus the possibility of working on 20m, 15m and 10m. There are several designs available on the web for this type of aerial so Google W3DZZ. One of the most comprehensive sets of instructions is by Len Paget G0ONX. Fine out more here:
http://www.users.icscotland.net/~len.paget/GM0ONX%20trap%20dipole.pdf

This would be my choice if I had the space, though since a dipole is a balanced aerial it would make more sense to use balanced twin feeder (as in the Spectrum Communications implementation of this design) rather than coaxial cable which is an un-balanced and more lossy feeder.



The W3DZZ Trapped Dipole - a balanced aerial, so use balanced twin feeder!

Here is a variation on the W3DZZ antenna by the Maidstone Amateur Radio Society that adds a dedicated 10 meter (28MHz) resonant element as a 'fan'.



W3DZZ Dipole Aerial design by the Maidstone Amateur Radio Society
http://www.btinternet.com/~shaun.scannell/club/w3dzz.htm

Moonraker supply a whole range of wire trap dipoles covering from 2 to 5 HF bands (MTD1; MTD2; MTD3; MTD4; MTD5; MTD6). Diamond also produce trapped wire antennas, the W-721, W-728 and W735. Comet and Diamond each produce similar interesting 5 band wire dipoles that utilize both traps and a fan arrangement - the Diamond W8010 and the Comet CWA-1000. If space really is limited then look out for KZJ Communications (dongo1950 on ebay) - he produces 'Limited Space Inductive Dipoles'. These are inductively loaded and shortened dipoles so they will have reduced efficiency, of course, but are very nicely made, so might be very useful in a tight spot.

Alpha Delta Communications produce a couple of substantial parallel dipole models: http://www.alphadeltacom.com

To obtain good efficiency and achieve a low angle of radiation, desirable for longer distance DX, a horizontal dipole needs to be installed at a good height - over 20 feet would be desirable and it is quite common to install horizontal dipoles at around 30 to 40 feet above ground level. This might be a problem at some QTH's, it certainly is at mine!

Allan Copland, GM1SXX comments: "The dipole will operate well on the band it has been sized for , if placed at a suitable height, but will also operate as a' three-half-wave' aerial at three times the frequency and so on, so it's not strictly a single band aerial. An 80M dipole (132 feet typical) will work nicely on 30 metres (three half waves) but not on 40m (two half waves)… because on 40M the feed-point is at a voltage node and not at a current node, for easy feeding. Most aerials are current fed.

The radiation pattern changes when a dipole is not used on its design frequency. The pattern will break up into multiple 'petals'. This can be either a disadvantage or an advantage depending on what you expect from it. Since most of us use co-ax, an UN-BAL should really be used to connect the unbalanced feeder to the balanced aerial, but how many people actually bother? Not many I suspect. It's possible of course to use a balanced feed-line system instead with a dipole and just have a delta match (no centre insulator… none needed). There are many choices and permutations, but in general, dipoles are centre fed at a point of current maximum (and minimum voltage).

A normal dipole is current fed but of course can be voltage fed instead. This is what's done in the EFHWA or Fuchs aerial where a resonant half wave wire is fed at one end (max voltage / min current) from an L/C tank, against a very short counterpoise wire.

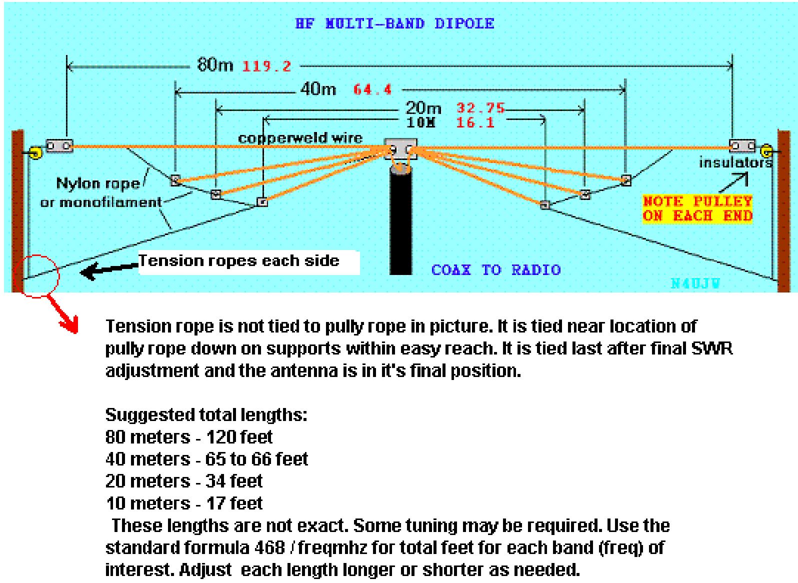
Fan Dipoles (a.k.a. Parallel) Dipoles:

Another design of multi band wire dipole is the fan dipole, or parallel dipole. A fan (or parallel) dipole will have, perhaps, two, three or four individual resonant dipoles with the arms arranged in a fan shape.

A fan dipole is a very handy way of using a dipole that will be resonant on several bands - typically three or four. The fan dipole (a.k.a. Parallel Dipole)

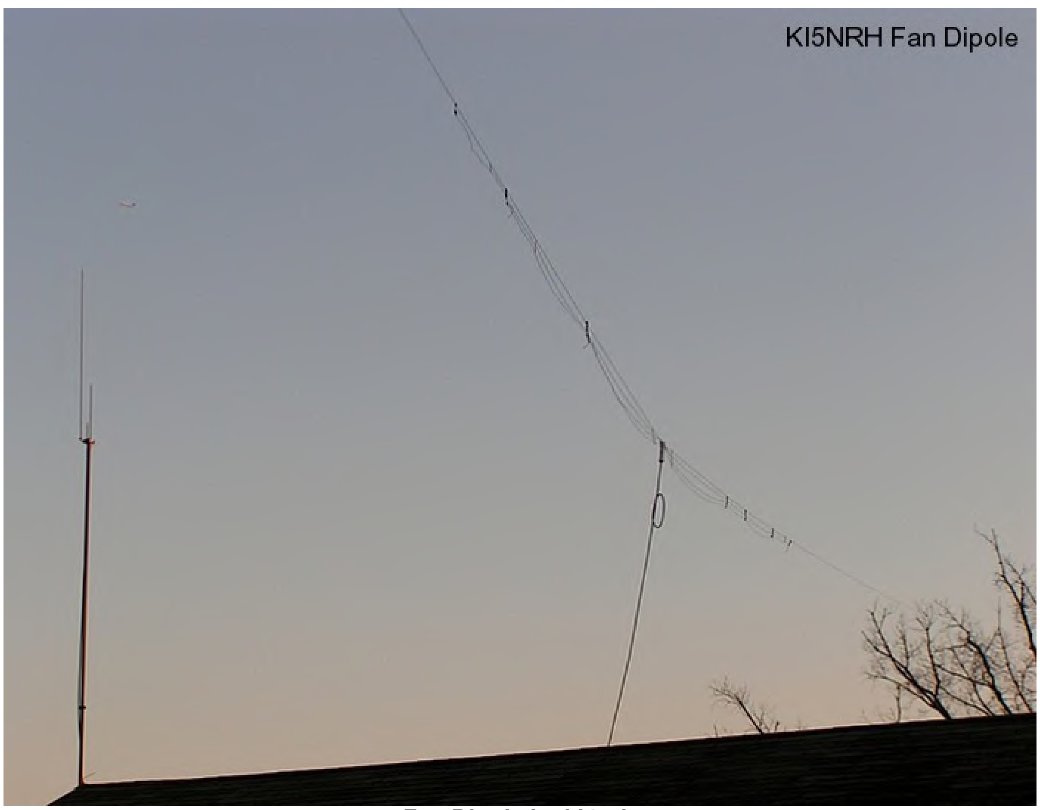
See M0WYM's page for a QRP Fan Dipole design: http://www.radiowymsey.org/FanDipole/fandiploe.htm

See this page for construction details: http://www.hamuniverse.com/multidipole.html

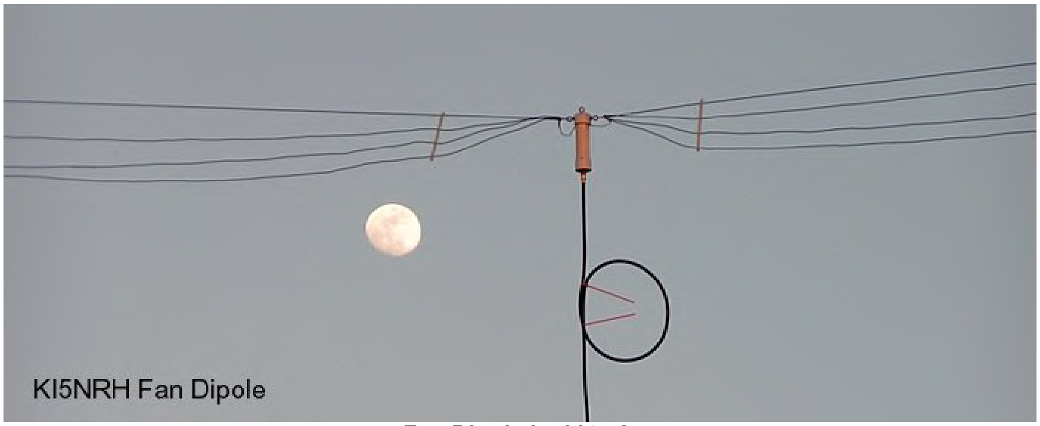


Fan Dipole shown on Ham Universe

KI4NRH built a really neat fan dipole shown in the photograph below:



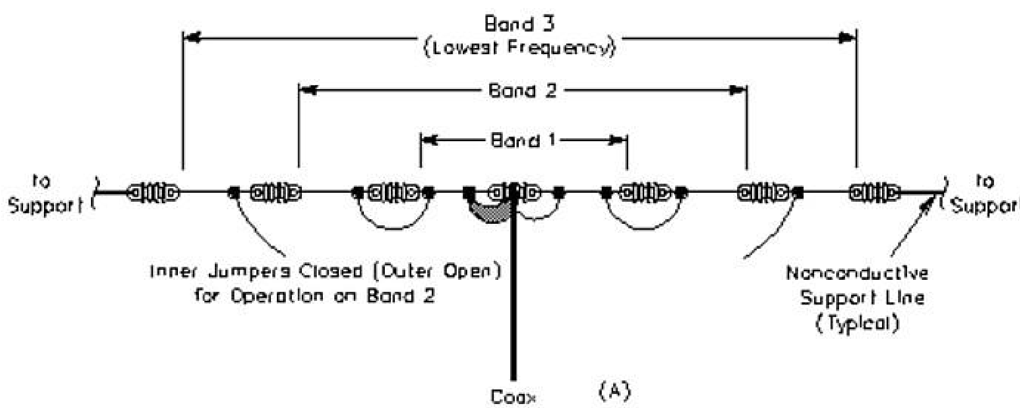
Fan Dipole by ki4nrh



Fan Dipole by ki4nrh
http://forums.qrz.com/showthread.php?t=159953

Link Dipoles

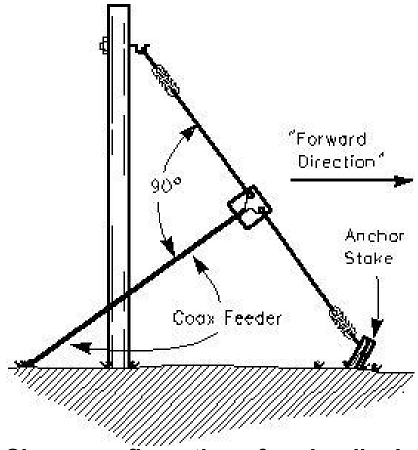
Link Dipoles (a.k.a Jumpered Dipoles) facilitate multi band operation by simply connecting the jumpers (one on each side of the aerial) to achieve the desired resonant band. Perhaps a bit bothersome for frequent band changes, but a very simple and effective aerial and very handy for portable operation, not to mention efficient for QRP.



Link Dipole - ref ARRL

Sloper Aerials

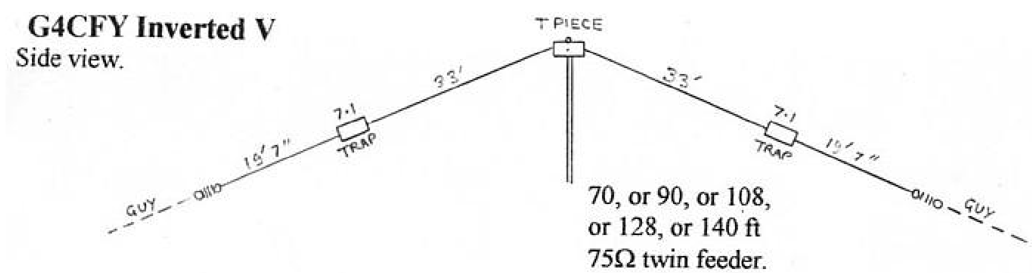
Alternatively a dipole can be installed as a sloper; one end fixed to a high point on the house or building, or a tall post maybe 8 to 10 metres high, with the other end attached to a lower point such as a post maybe 3 or 4 metres high. This will give the aerial some directivity.



Sloper configuration of a wire dipole

Inverted V Aerials

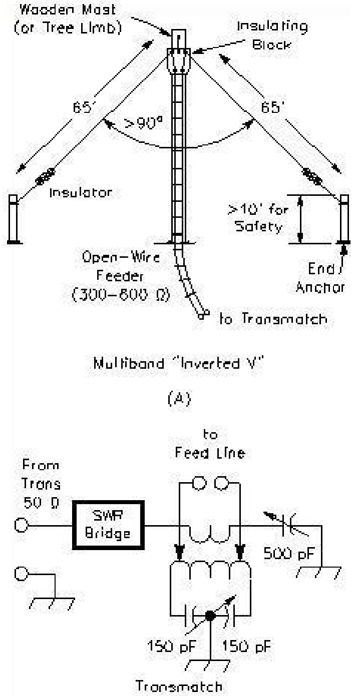
Another option maybe to support the dipole at its centre on a tall pole, or roof apex, with each end sloping downwards to lower fixing points. This will give the aerial an upside down V shape. As with a sloper, the Inverted V arrangement will give the aerial some directivity - a different radiation pattern compared to a straight horizontal dipole.



Spectrum Communications G4CFY Trapped Dipole in "Inverted V" configuration
http://www.spectrumcomms.co.uk

The Classic Doublet Antenna Again. This time in an Inverted V formation:

Using an Inverted V can help fit a dipole into a slightly restricted space. The Inverted V arrangement can be used for single band resonant dipoles, trapped dipoles and fan dipoles. The Doublet must be fed with Ladder Line or Open Wire balanced feeder for efficient Multi-Band operation.



At A, details for an inverted V fed with open-wire line for multi-band HF operation. A Transmatch is shown at B, suitable for matching the antenna to the transmitter over a wide frequency range. The included angle between the two legs should be greater than 90° for best performance. [ref: QSL.net]

Vee Configuration

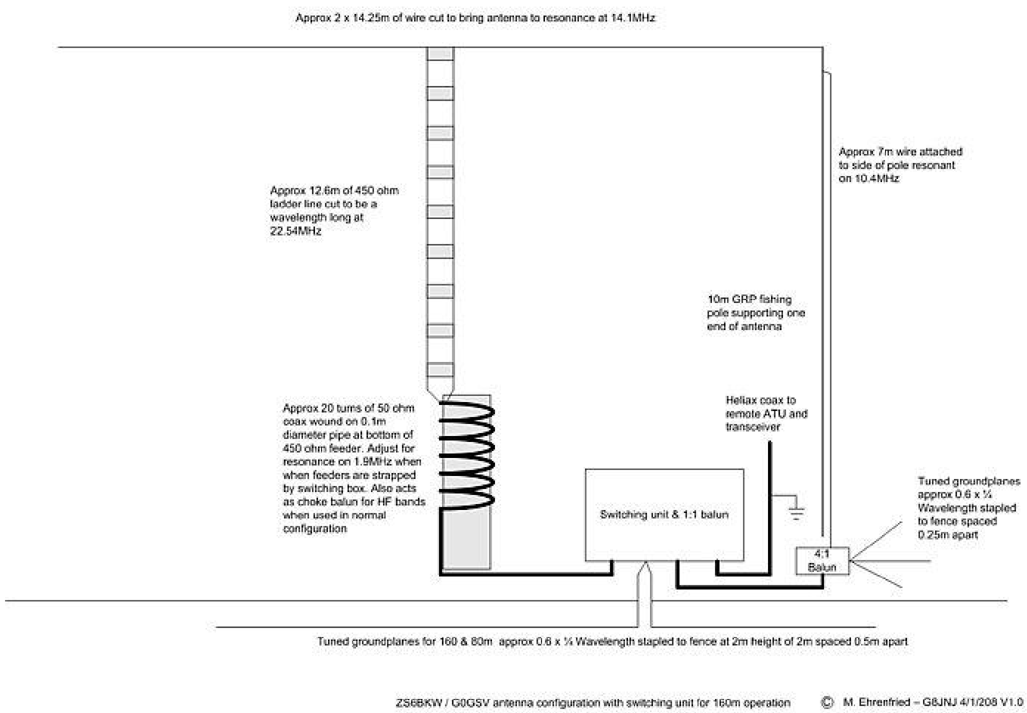
Comet and Diamond produce Vee antennas that can be mounted on the side of a building at roof height, or on a pole, telescopic pole or other suitable support. These are trapped dipoles in an upright V configuration, not made of wire but of aluminium tubing for solid construction. Typically covering 40m, 20m, 15m and 10m. The Comet model is H-422V. The Diamond Model is HFV5 which also covers 6m.

These are shortened antennas so cannot be expected to have high performance on the lower HF bands, but if space is restricted the RF compromise may one that has to be taken.

Comet H-422V
http://www.cometantenna.com

Diamond HFV5 Antenna
http://www.diamond-ant.co.jp/english/amateur/antenna/ante_2base/ante_base7.html

Thoughts from Martin G8JNJ on multi-band wire antennas:



Multiband Wire Antenna by Martin G8JNJ
http://g8jnj.webs.com/

Linear Loading

Linear loading a dipole can reduce the length to help fit a ling dipole into a shorted space by essentially folding back some of the dipole elements. Here is a design by K4VX for a 7MHz Linear Loaded Dipole:
http://www.arrl.org/files/file/Technology/tis/info/pdf/0207040.pdf

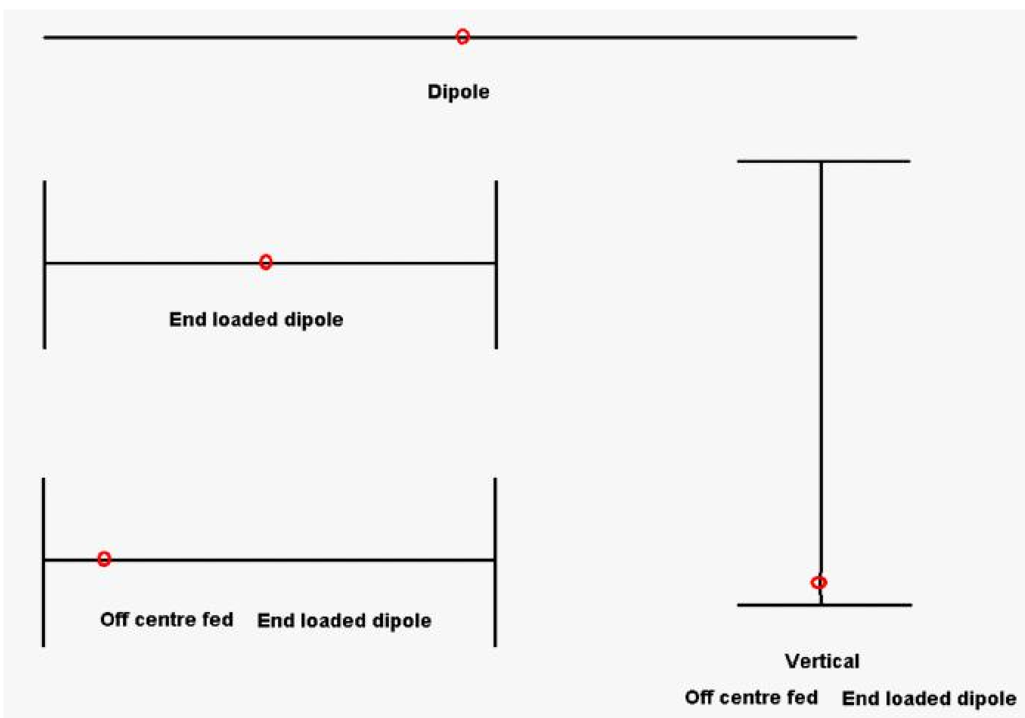
End Loaded Dipole

End loading can also help reduce the size of antennas, particularly useful for dipoles used on the 80m and 160m bands.

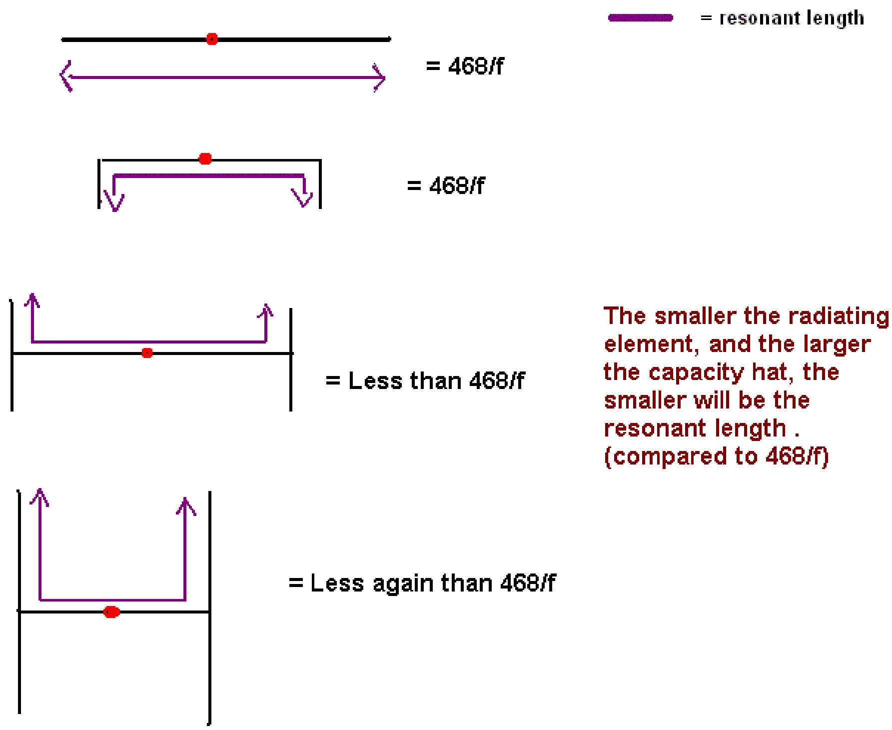
An end loaded dipole will produce an antenna that is H shaped. There are several commercial designs available produced in designs that cover a single band and others that cover multiple bands. The version shown below is only 3 metres tall so will be suitable for very unobtrusive, low profile use. It is the ProAntennas Multi-band I-PRO: 20m 17m 15m 12m 11m & 10m which uses a capacity hat with some loading at the centre.
http://www.proantennas.co.uk/

Other similar antennas were available from Force12 Antennas in the form of, amongst others, the Sigma 5 and Sigma GT5. The Sigma design used T-bars at each end of the vertical dipole for loading technique and off-center loading coils. http://www.force12inc.com This was supplied supplied in the UK by Vine Antennas at one time http://www.vinecom.co.uk . Transworld Antennas also have produce antennaa using a similar concept - the TW2010 Adventurer and Backpacker http://transworldantennas.com

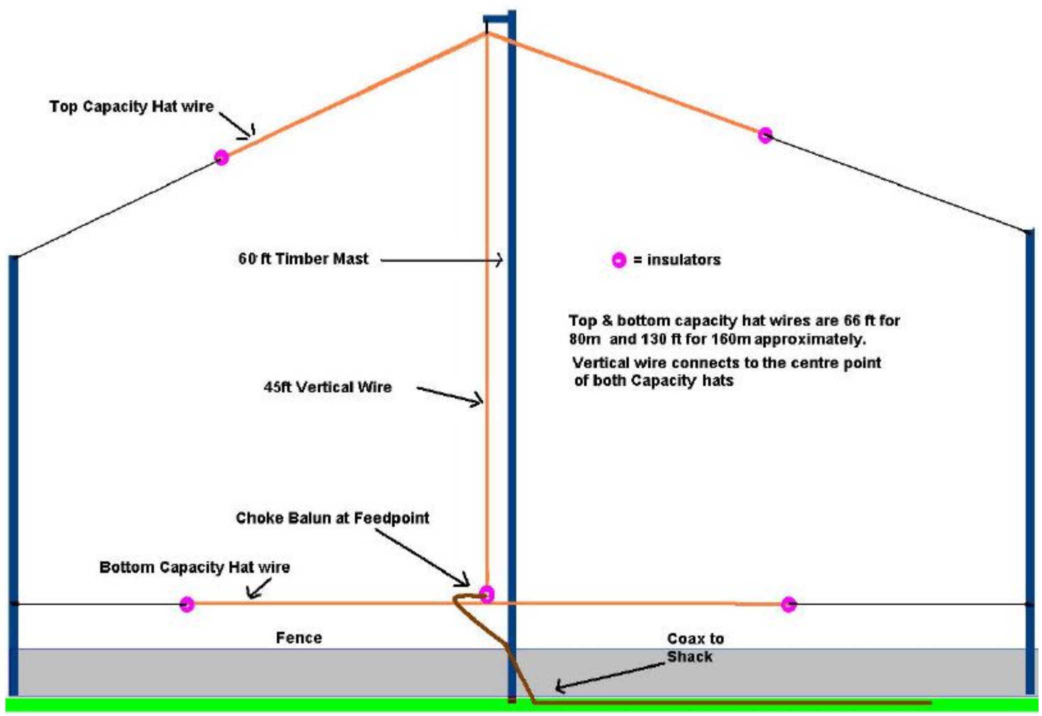
K9AY Notes that: "I have come to the conclusion from my experiments, readings and observations, that a capacity hatted vertical dipole, a few feet over ground, is less compromised than a 1/4 w/l vertical of the same height fed against a less than perfect ground. Let's face it, most amateur's ground systems are mediocre at best. Also, the dipole is easier and cheaper to rig, and is two dimensional..Very important in my situation, as I cannot run out radials on my neighbours property. Or, to quote W4RNL.."Since only a handful of hams can ever have 160-meter antennas high enough to yield a low angle DX signal, more practical are vertical arrays such as yours. Vertical dipoles with hats (or Tees) save a plethora of wire needed by monopoles." http://www.dxzone.com/cgi-bin/dir/jump2.cgi?ID=7466



Information by K9AY



Information by K9AY

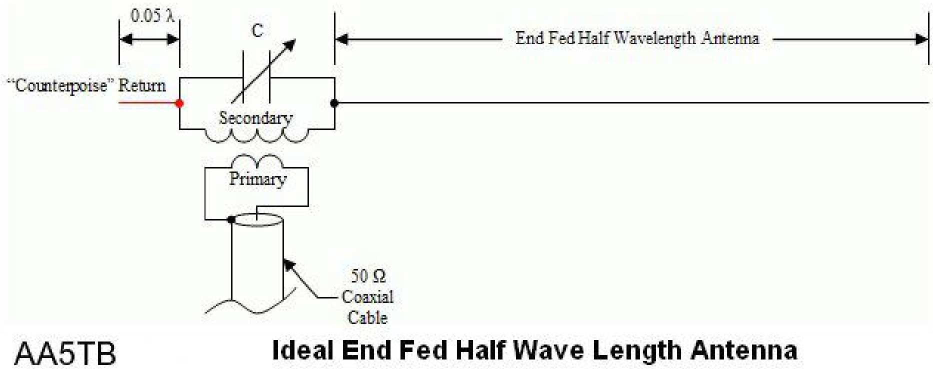


Interesting concepts from K9AY

End Fed Half Wave Antenna

The End Fed Half Wave Antenna (EFHWA) is fed at a voltage node via a parallel resonant circuit against a ‘short counterpoise’, it is a favourite of backpackers and outdoor types. It can be considered as a half wave dipole that’s end-fed at a voltage node rather than the current node, as is more usual. This is a very handy arrangement for portable QRP work.

EFHWA Link: http://www.aa5tb.com/efha.html



End Fed Half Wave Antenna by AA5TB
http://www.aa5tb.com/efha.html

"I suspect that nothing new or radical has happened in the field of radio aerials in a VERY long time, like at least many tens of decades. Most of the new wonder aerials are really a con. Choke off the feed-line and then see how good they really are. Prime among the baddies is the CFA. It doesn't really work, at least if you place a choke in the feed-line. With any real aerial, there should be minimal radiation from the feed system… so a choke should really make no difference at all, but for the CFA it does! The CFA is not alone, there are others. The popular G5RV is another design with a radiating feed, deliberately so, but of course G5RV planned it that way. He wasn't cheating… merely being a bit devious, to make it multi-band".

"Lots of stuff to pass on to my fellow radio club members, most of whom are of the 'if it's not expensive, it can't be any good' school of thought when it comes to aerials. Nothing of course could be further from the truth! Aerials are one area where it makes a lot of sense to build our own." : Website of GM1SXX - www.observations.biz

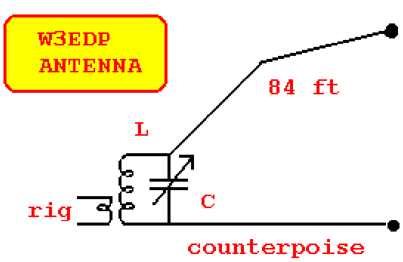
Thanks for your email Allan. It's a good idea to point out that an antenna could be pressed into use on odd multiples of its resonant frequency, hence a 3.6MHz antenna for 80m could be useful near the 30 metre, 10.1MHz, band - near to the third harmonic of 3.5 MHz although, as you observe, the radiation pattern may be quite distorted from the traditionally expected dipole pattern and be more petal shaped. The same goes for a 7.1 MHz antenna for 40m being usable on its third harmonic of 21.3 MHz for the 15m band - a 40m dipole being three half waves an the 21 MHz band.

I have not experimented with a full size 80m dipole, but I would guess that it might be useful at 5 times 3.6Mhz in the 18 MHz / 17m band?

The point made about feeding a familiar dipole at the current node rather than the voltage node is obviously very important and, I imagine, sometimes overlooked.

PLANS: Download the pdf plans produced by G0KYA here > More from G0KYA here: http://g0kya.blogspot.com

W3EDP Antenna



Frank, G3YCC comments on his website: The W3EDP needs a simple matching unit is needed to couple the wire to the rig and a counterpoise is required for some bands, however there is room for experimentation. It has been shown that different lengths or removal of the counterpoise altogether, can improve performance, as described in RadCom, August 1996 by G3LCK.

The Tuning capacitor in the AMU can be a 365 - 500pF broadcast type or a miniature version is OK for QRP use.

Counterpoise lengths: 3.5 & 7.0Mhz - 17ft ; 14Mhz - 6.5ft ; 28Mhz - none

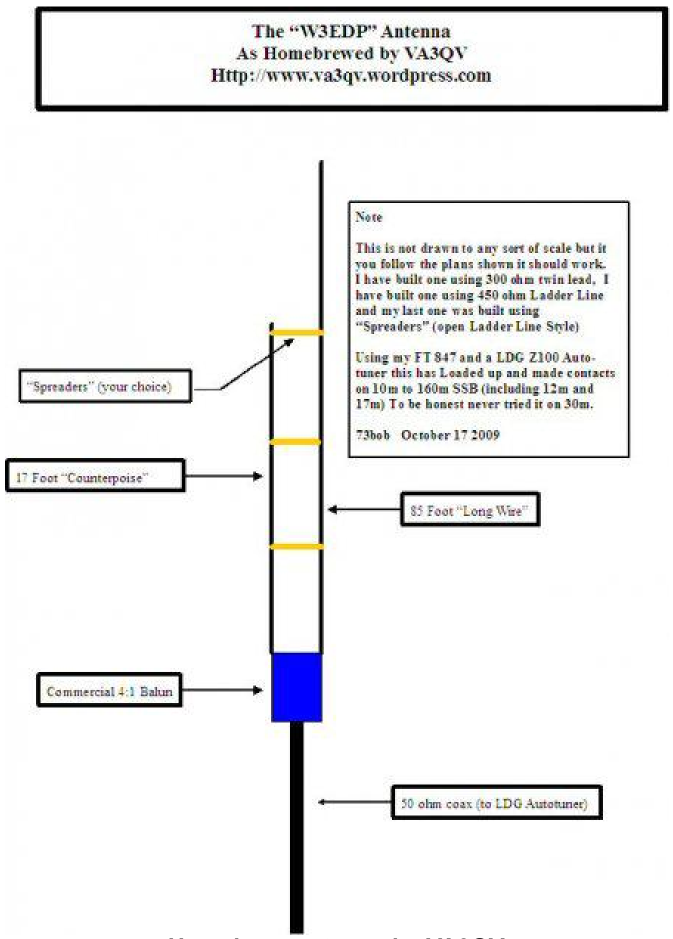
Tuning Unit: Values for coils in the unit, based on a 2 inch former and 16 swg wire:
3.5Mhz 21 turns ; 7.0Mhz 7 turns ; 14.0Mhz - 5 turns.

K3HRN Notes: "Some folks have told me the modifications below make the antenna something other than a W3EDP. I can tell you that it works very well with 5 watts. Create a "bundle" of counterpoise wires, 1/4 wave length for each band you will use. Attach the bundle to the tuner in place of the counterpoise pictured above. Be cautious, 1/4 wave length elements can have high RF voltages present, even at QRP power levels. I've been able to work 160-10, including WARC bands with this type of antenna".

W3EDP or Zepp ?

It's the antenna favoured by VA3QV for all band Portable QRP operating!

VA3QV uses this home-brewed antenna with a small LDG Z100 antenna tuner for portable QRP work.



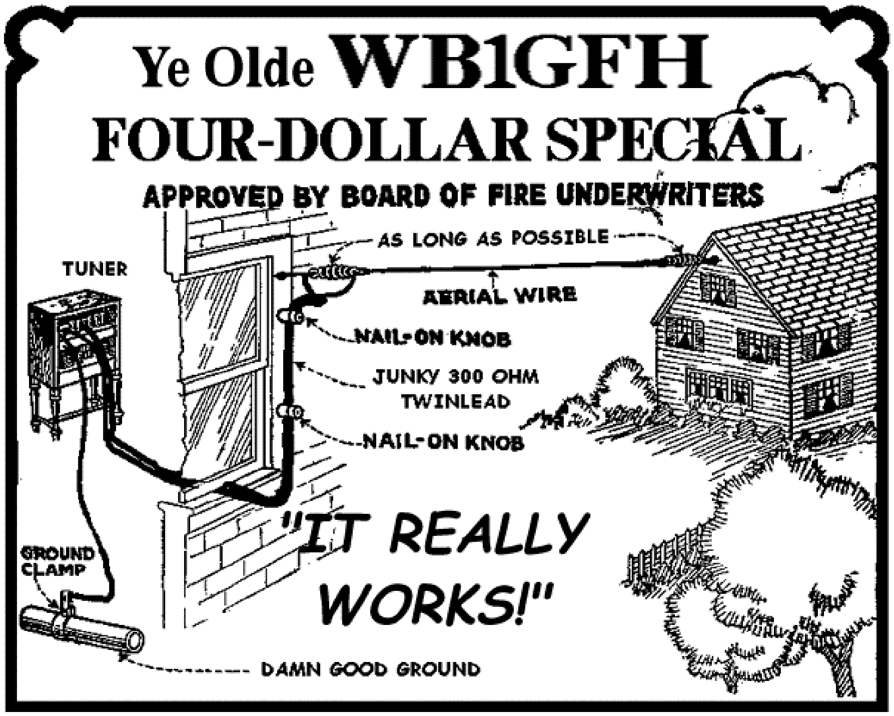
Homebrew antenna by VA3QV
http://va3qv.wordpress.com

Ye Olde Zepp

Marconi spins in his grave every time a ham buys an aerial instead of building it ! (W1GFH)

Here is a wonderful olde worlde style cartoon from WB1GFH that certainly inspires antenna experimentation with

antenna designs:

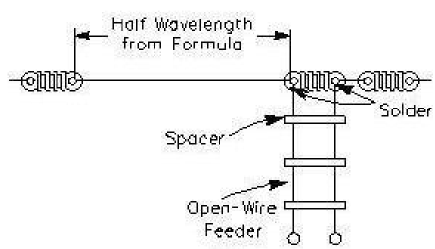


Superb. I love it!

See more inspiration from Joe Tyburczy, W1GFH, here: http://www.hamuniverse.com/fourdollarspecialw1gfh.html

End Fed Zepp "Zepp"

The End Fed Zepp consists of a 1/2 wavelength horizontal radiator wire connected to one conductor of a length of parallel open wire feeder, 300 ohm or 450 ohm twin feeder. The feeder is often quoted as being 1/4 wavelength long.

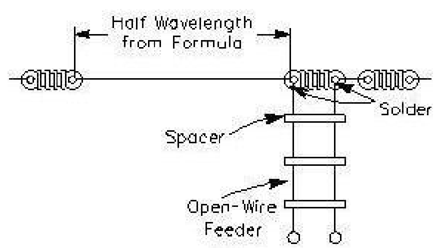


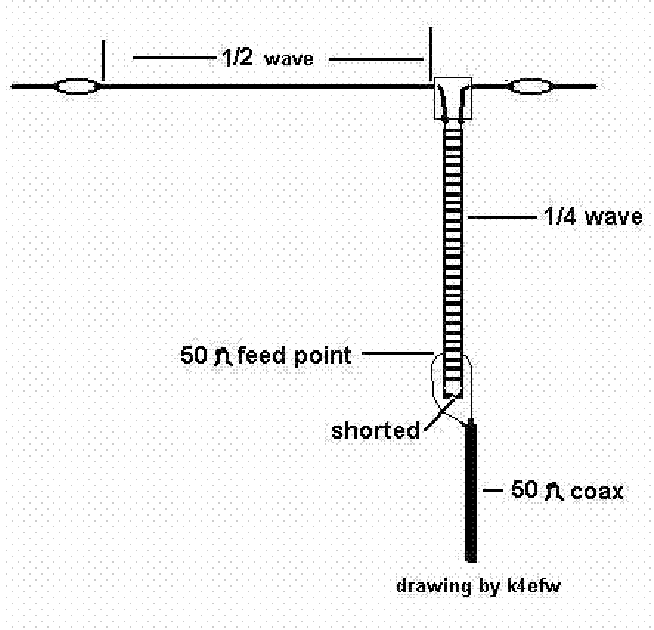
Basic design of an end fed Zepp

G Whip Antenna Products manufacture and supply a version of the Zepp antenna. Geoff G4ICD explains: "The end fed Zepp shown below has no counterpoise, just a tuned circuit in the feedpoint plus a half wave radiator. This is a most interesting antenna and can be used on other bands with the use of an Antenna Matching Unit."

A high quality End Fed Zepp style antenna: This variation uses a tuned circuit rather than a tuned twin feeder.
Supplied by G Whip Antenna Products of the UK
www.gwhip.co.uk

The end fed zepp is a popular antenna often used to save space and gets its name from the fact that it was used as an end fed wire trailing out from the rear of Zeppelin airships. It consists of a 1/2 wavelength horizontal radiator wire connected to one conductor of a length of parallel 300 ohm or 450 ohm twin feeder, often quoted as being 1/4 wavelength long.





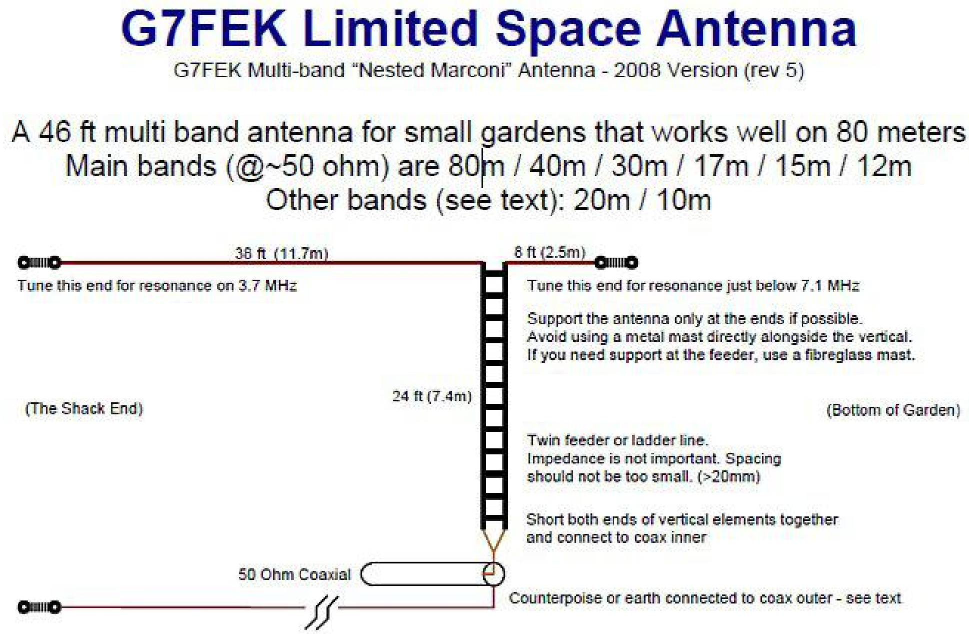
Zepp Antenna by K4EFW
http://www.hamuniverse.com/n4jaantennabook.html

K4EFW notes: "...A half-wave resonant antenna can be fed from its end. When fed this way, it is also known as an end-fed zepp. An end-fed zepp will work on its fundamental frequency and on odd and even harmonic frequencies. The end of a half-wave antenna has very high impedance, and an antenna fed this way is said to be voltage fed. Feeding a half-wave resonant dipole in the center means it is current fed. The normal way of feeding the end-fed antenna is with ladder-line. One side of the ladder-line is connected to one end of the antenna and the other side of the ladder-line is connected to nothing. To secure the unconnected side of the ladder-line, it is connected to a short wire running between two insulators. Since the antenna is connected at its high impedance point, no current flows into an antenna, but there will be a large current in the center of this antenna. No current flows from the open side of the feed-line because it is at a zero current point. The end-fed zepp can be matched by cutting the ladder-line to a quarter wavelength with the bottom end of the ladder-line shorted. A certain distance above the short is a 50-ohm feet-point and it can be fed directly with coax. You will have to find the 50-ohm point by trial and error. This method of feed makes it a single band antenna". Quoted from K4EFW.

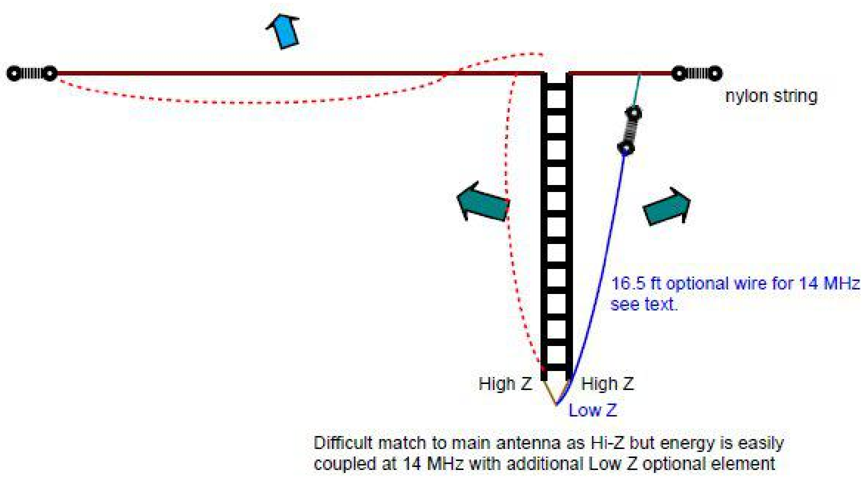
Here is a commercial product made by G-Whip Antennas of the UK offering their version of a Zepp antenna design: http://www.gwhip.co.uk/

Martin G8JNJ highlights a very interesting antenna designed by Mike G7FEK here:-

The G7FEK antenna goes several stages further than the simple single band End Fed Zepp. G7FEK has produced a design for Multi-Band operation claimed to offer much improved performance over a half sized G5RV or 'Windom' antenna while additionally providing access to the 80 Metre Band.



G7FEK Limited Space Multi-Band Antenna



Adding 14MHz to the G7FEK Limited Space Multi-Band Antenna

The G7FEK design will allow operation on 80m / 40m / 30m / 17m / 15m / 12m with the possibility to add the 20m band.

G7FEK Plans: Download the plans for the G7FEK antenna from G7FEK's website here or from this website here

Tuner Design For Half Wave Vertical and Similar Length End Fed Antennas by G4FGQ

http://www.radioaficion.com/HamNews/articles/8218-tuner-design-for-half-wave-vertical-a-similar-length-end-fed-antennas.html

Off Centre Fed Dipole (OCFD) - so called 'Windom' Antenna

The "Windom Antenna" was described by Loren G. Windom W8GZ. It could be an ideal wire aerial for use in restricted spaces for multi-band operation. It may also be an good candidate for portable work.

It is a wire antenna, similar to a dipole, but unlike a dipole or doublet which is fed at the exact centre, a Windom or Off Centre Fed Dipole, as the name suggests, has the feed point off center.

Current versions of the Windom are not actually Windom antennas at all - instead they are fed with coaxial cable and have a balun placed at the feed point. These are Off Centre Fed Dipole antennas - OCFD. They are similar in

appearance to a true wire Windom, but they are different.

As with all aerials the aerial should be as high as possible. With the feed point at between 20 and 40 feet above ground the typical claimed impedance will be somewhere in the region of 200 Ohms so a 4:1 balun will typically be required. At greater heights, and depending upon the exact position of the feed point, the impedance may be higher and a 5:1 or 6:1 balun might be a better choice although balun losses will be greater.

The point at which a Windom is fed in the original design, which used an open wire to feed the aerial, was 15 percent off-centre. The current designs, which are fed with coaxial cable, are typically fed about 33 percent off centre, so one leg is 67 percent of the total length and the other leg is 33 percent of the overall length of the aerial.

The bands that are covered depends upon the overall length of the aerial:

11 metres long (approx) should cover 20m, 15m and 10m and the WARC bands with a tuner.

21 metres long (approx) should cover 40m, 20m, 15m and the 10m bands and WARC with a tuner.

41 metres long (approx) should cover 80m, 40m, 20m, 15m and 10m and WARC with a tuner.

80 metres long (approx) should cover 160m, 80m, 40m, 20m, 15m and 10m and WARC with a tuner.

Cut the aerial for the lowest band to be used. In imperial measurements using a familiar formula:
The longer leg will be 468 divided by the frequency and multiplied by .67 = length in feet
The shorter leg will be 468 divided by the frequency and multiplied by .33 = length in feet

OCFD Formulas:

The offset proportions differ according to which sources one refers. Some sources suggest 33% / 67% but other dimensions are also to be found:

62.2% for one side and 37.8% for the other leg. So:
The longer leg will be 468 divided by the frequency and multiplied by .622 = length in feet
The shorter leg will be 468 divided by the frequency and multiplied by .378 = length in feet
[Source: New Caroline Windom - http://www.hamuniverse.com/k4iwlnewwindom.html]

Other ideas:

The proportions of 69% / 37% are used by Buxcomm who say that "One third plus two thirds will not work. Use the formula below, as is: Do not be concerned with the off-set of the feed point, as this formula takes into consideration, the correct off-set for feeding the (BUXCOMM) Windom.for the other leg." **So:**
The longer leg will be 468 divided by the frequency and multiplied by .69 = length in feet
The shorter leg will be 468 divided by the frequency and multiplied by .37 = length in feet
[Source Buxcom: http://www.buxcomm.com/windom_files/WINDOM.htm]

Given the fairly simple formula it should be quite easy to make an OCFD Windom - however a Windom can be purchased at very reasonable cost commercially, for example from M0CVO at http://m0cvoantennas.webs.com alternatively G-Whip Antennas of the UK supply extremely high quality, high efficiency 4:1 baluns (and other baluns) that could be used at the centre of any Off Centre Fed Dipole - just add the correct wire lengths to each side.

Geoff G4ICD / GJ4ICD of GWhip highlighted his website which has an interesting page with comments concerning the quality and construction of balun products. This feature on the G-Whip site can be seen here: http://www.g4icd.co.uk/baluns.htm

Here is a photograph of the very high quality G-Whip OCFD antenna product www.gwhip.co.uk :

An 'Off Set Centre Dipole' - OSCD - Fed made by G Whip Antennas
G-Whip Antennas - www.gwhip.co.uk

HW-20HP Off Centre Fed Dipole - produced by M0CVO
6.76 metres long one side and 3.38 metres on the other side.
http://m0cvoantennas.webs.com

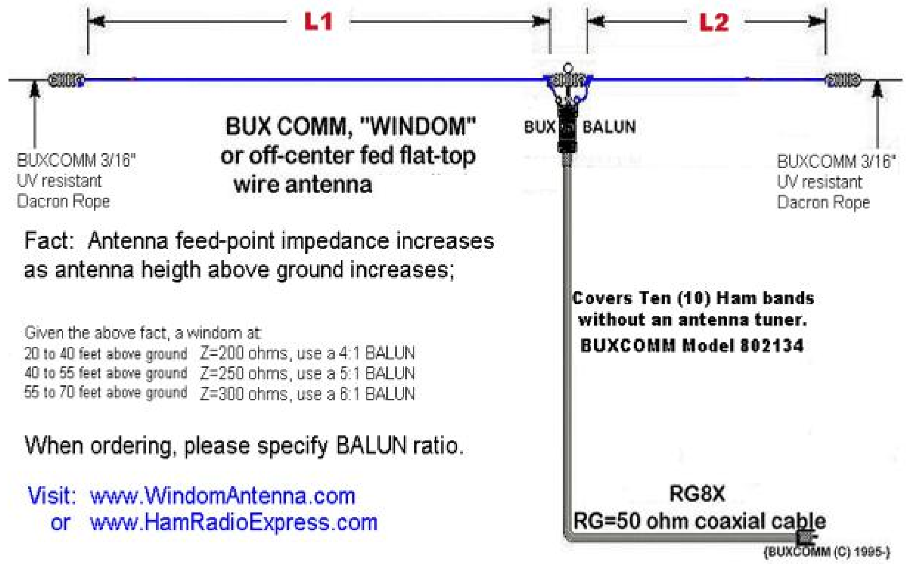
M0CVO produces a couple of off centre fed dipoles, the HW-40HP and the HW-20HP. Both antennas handle 400 watts - the HP designation refers to high power.

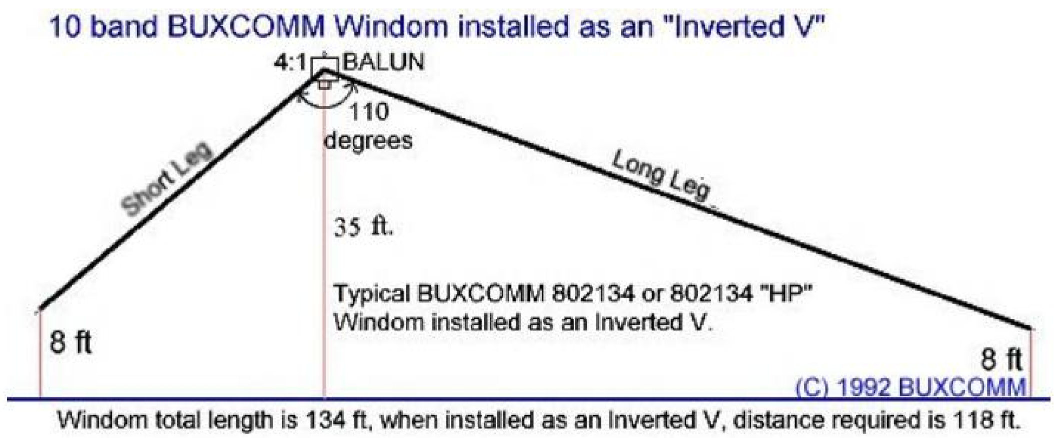
The M0CVO HW-20HP is 10.14m in length and covers 6 bands - 20, 17, 15, 12, 10 & 6m, no ATU, and is said to also work on 30m & 40m with an ATU. Can be mounted as a horizontal, inverted vee or a sloper. VSWR is said to be 1.4 on 20m, 2.8 on 17m, 1.1 on 15m, 1.0 on 12m, 1.0 on 10m and 1.5 on 6m. The antenna is6.76 metres long on one side and 3.38 metres long on the other side. This uses a 66.6% / 33.3% formula.

The HW-20P was reviewed by Steve Nichols, G0KYA, in the January 2012 edition of RadCom.

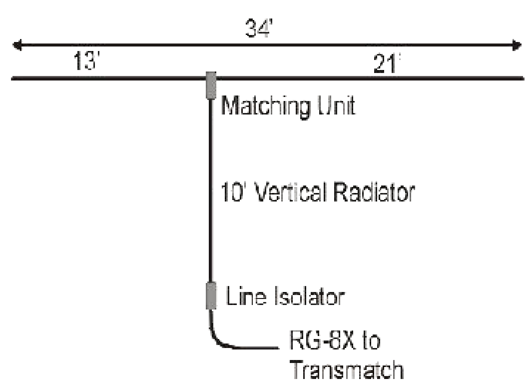
The HW-40HP is 20.28m in length and will operate on 40, 20 and 10m without an ATU and 80, 60, 15, 6 and WARC Bands with an ATU. (Presuably one leg is 13.52 metres long and the other 6.76 metres if it follows the same 66.6% / 33.3% formula as the HW-20HP).

Here is a graphic of an Off Centre Fed Dipole typical of those available in the USA:





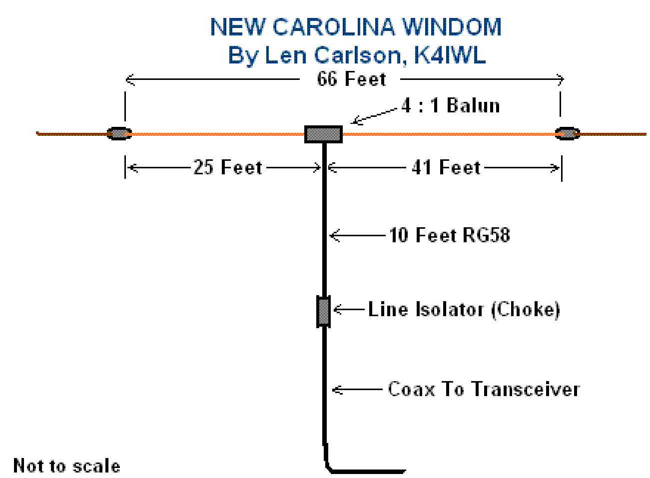
http://www.buxcomm.com



Carolina Windom for 20 metres to 10 metres
http://www.radioworks.com/ccwcover.html

M0UKD - 4:1 balun. It is 17 bifilar turns on a half inch ferrite rod. 50Ω - 200Ω, 1-30MHz
http://www.m0ukd.com/Carolina_Windom/index.php

M0UKD Line isolator - 10 turns RG8 on a half inch ferrite rod
http://www.m0ukd.com/Carolina_Windom/index.php



Windom design for 40m 20m 15m and 10m by K4IWL
http://www.hamuniverse.com/k4iwlnewwindom.html

More information on this general subject at BucksCom: http://www.packetradio.com/windom.htm **or** http://www.buckscom.com/pdfzips/windom.pdf

Commercial Suppliers:

G-WHIP Antennas (UK) : http://www.gwhip.co.uk
M0CVO OCFD Antennas (UK) : http://m0cvoantennas.webs.com

In the U.S.A:
Bux Comm Windom Antennas : http://www.buxcomm.com
Buck Master OFC Dipole Antennas : http://hamcall.net/
Alpha Delta : http://www.alphadeltacom.com
Carolina Windom : http://www.radioworks.com/ccwcover.html

See some Windom - Off Centre Fed Dipole - designs at these links:
http://users.erols.com/k3mt/windom/windom.htm
http://www.dxzone.com/cgi-bin/dir/jump2.cgi?ID=7478
http://www.radioelectronicschool.net/files/downloads/ocfdipole.pdf
http://www.hamuniverse.com/k4iwlnewwindom.html
http://www.g4nsj.co.uk/windom.shtml
http://www.m0ukd.com/Carolina_Windom/index.php

Semi-Permanent Antenna Installations

If it impossible to install a permanent aerial, then another option is to use an antenna designed for portable or mobile work deploying it only as and when necessary in the back yard or garden - perhaps supported with a portable tripod and/or guy ropes.

From the ideas above it should be possible to rig up a semi-permanent or removable antenna for low visual impact.

There are also very many portable antennas produced commercially that might be very useful to utilize on a semi-permanent basis. Commercially bought antennas can be very expensive indeed, especially when compared to 'home brew' aerials, but examples that immediately spring to mind for consideration include: The DMV-Pro, I-Pro, G Whip or G Whip Backpacker, the TW2010 from Transworld Antennas, the Sigma5 from Force 12 and aerials from SuperAntennas. Sandpiper Aerial Technology offer a very good choice of aerials such as the MV and MV-Portable, Buttie or Walkabout mk11 at very attractive prices. http://www.sandpiperaerials.co.uk There are very many other compact and portable antenna systems that are widely available. Check out all the amateur radio dealers for more ideas.

The DMV-Pro Antenna from ProAntennas (shown above) could be used in a back garden whenever required as could the company's I-Pro antenna. The DMV-Pro uses two fibreglass arms that allow the wire aerial to be supported in a number of different configurations such a "V" shaped, "L" shaped, "M" shaped and Delta. The aerial elements are fed to a 4:1 balun using low loss twin feeder, the balun is then connected to an auto ATU, such as the LDG Z-11 Pro, which is connected to the transceiver using coaxial cable. A versatile idea that could also be implemented on a DIY basis with a little experimentation! http://www.proantennas.co.uk

Geoff G4ICD / GJ4ICD mentions the original design, the JJ1VKL published in CQ ham radio Sep' 2000 in Japan. "This one goes back to 2000 and is now copied by several antenna manufacturers in the UK" It is an HF multi-band Delta loop antenna for 3.5-50MHz
http://www.geocities.jp/yoshiki_ja/deltae.htm

An Original Delta Loop design by JJ1VKL
Read more here: http://www.geocities.jp/yoshiki_ja/deltae.htm

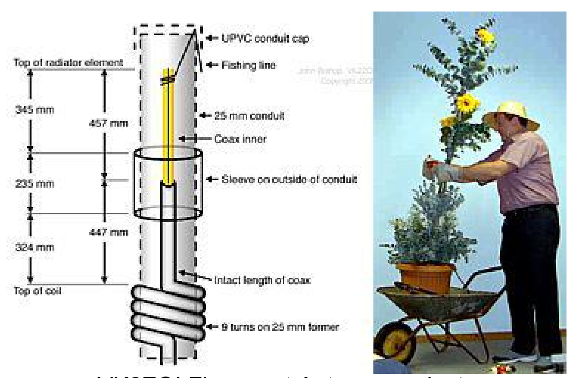
Delta Loop by Arthur M0PLK (SQ2PLK)
Details at http://pdxa.one.pl/articles.php?article_id=17
Available at http://ham-radio.urbasket.eu and http://www.vpa-systems.pl/

STEALTH / COVERT / HIDDEN or DISGUISED ANTENNAS:

Ideas from **G4ILO** - Stealth Antennas: http://www.g4ilo.com/stealth.html

VK2ZOI - "Flowerpot" Antennas

Some ideas by VK2ZOI about producing inconspicuous antennas - perhaps disguised as a plant in a flower pot! There are ideas for 6 metre, 2metre and 70cm antennas including a dual band 2,/70cm design.



VK2ZOI Flowerpot Antenna projects
http://vk2zoi.com

All Band HF Vertical Antennas (non resonant) - 'Untennas'

So this is where the search for a multi-band antenna begins. It's a difficult task especially if space is limited. First considerations might lie with the commercially available options that are available. Commercially manufactured aerials are available at widely varying price points - perhaps from under £100 to many many £100's

One of the first commercial multi-band antennas that many keen new amateurs come across is something like the Comet CHA250B, or the Diamond BB7V or Moonraker GP2500 (pictured right). These are broad-band antennas and look like large CB antennas with a matching network at the base. Such antennas claim to allow operation of all bands between 80 metres and 6 metres with acceptably low v.s.w.r. Sounds like the perfect multi-band solution, especially as Comet and Moonraker are well known names that make excellent products.

These multi-band antennas have their critics though: Sure enough, they exhibit a seemingly acceptably low v.s.w.r. across the whole of HF, but low v.s.w.r. isn't everything. Ctitics do, in fact, call these types of broadband antennas glorified dummy loads - a bit unfair possibly, but maybe they have a point when most of your transmitter's precious power is wasted as heat rather than radiated as a useful RF signal!

The only way a simple, single vertical radiator can be made to work on across such a wide range of frequencies is by having a broad band matching transformer at the base of the radiator. This will inevitably result in the absorption of some - or much of the transmitter's power - the power loss represented by the heating up of the coils/transformer rather than actually being radiated as a useful signal by the antenna's vertical element.

Such antennas could present a loss of around 6 - 12 dB compared to a resonant antenna - how do do fancy putting all 100 of your precious watts in to the antenna and only getting 6.31 watts of effective power radiated?

Maybe that's a bit simplistic, so Martin G8JNJ has many superb articles analyzing the CHA250B and similar antenna designs here: http://g8jnj.webs.com/cometcha250b.htm

The article Anatomy Of The Comet CHA250B by VK5ZBD can be found here:
http://www.radiomanual.info/schemi/ACC_antenna/Comet_CHA-250BX2_anatomy.pdf
(Formerly found at this site http://www.vk5zdb.com/CHA250BXII.htm)

G8JNJ is also developing a better version of this type of antenna here:
http://g8jnj.webs.com/broadbandhfvertical.htm

I admit that, due to limited space, I considered this type of antenna when first starting out - but in the end dismissed them due to the extreme inefficiency and power loss problems. They should not be entirely discounted however, because if this really is all that can be accommodated at one's QTH then at least such an aerial will at get you on the air - and on all bands - at least in some sort of fashion. Many amateurs use these aerials with success, so they do have a place. Have a look and decide for yourself.

Other similar types of broad-band antenna:

There are a number of very similar designs (i.e. longish vertical radiator, with a transformer / unun at the base) available from some other British suppliers:

The G Pro-Whip 'Widebander' antenna (see http://www.gwhip.co.uk/);
The ProWhip Portable Antenna (see http://www.prowhipantennas.co.uk/);
Snowdonia Radio Company (SRC) - various types of wideband antennas (see http://www.snowdonia-radio-company.co.uk)

All these antennas appear to be based around an UNUN (typically 9:1) matching transformer at the base of the aerial. These aerials cost considerably less than those previously mentioned. The G Pro Whip and Pro Whip Portable offer particularly convenient portable operating opportunities as they are based on one of my favourite methods of antenna support - a long telescopic fibreglass (fishing) pole. Really neat!

For the 'fishing pole' types, essentially there is a vertical radiating wire of about 7 to 10 meters long, a 10m long horizontal counterpoise wire and the 9:1 unun at the base. This makes for a simple and attractive installation proposition (but remember the penalty of power losses) - all these aerials will be easy to install for permanent, semi-permanent use and easily removable or portable operating.

Considering the 10 meter vertical type, the performance on 40 meters (1/4 wave) should be quite reasonable, with reduced performance on other bands.

G-WHIP G Pro Whip antennas (now discontinued)
by Geoff Brown G4ICD
2011/2 - See G-WHIP'S WideBander Antenna as an alternative
http://www.gwhip.co.uk/

Buy (or build) a 9:1 UNUN and Make Your Own:

If you already have a 10m telescopic fibreglass fishing pole and some wire, then you could easily wind a 9:1 unun, or even buy one from suppliers such as G WHip Antenna products for a reasonable cost. So, you could make your own aerial with 10m vertical radiator working against the 10m counterpoise and fed to the ATU via the 9:1 unun at the aerial's base - just for fun, for experimentation, analysis or for permanent installation or portable work. (The telescopic pole must be fibreglass not carbon fibre)

Martin G8JNJ, suggests that a slightly better way to home-brew a broadband HF aerial might be to cut a vertical aerial for about 8.5 MHz, i.e. not a resonant 1/4 wave on any amateur band, but optimised to present a moderate impedance on as many bands as possible. In which case the vertical wire would be about 8.8 metres long, working against the counterpoise, and fed to the a.t.u. via an unun - perhaps 6:1 or 9:1 - this is all open to further research and experimentation! See http://g8jnj.webs.com/currentprojects.htm

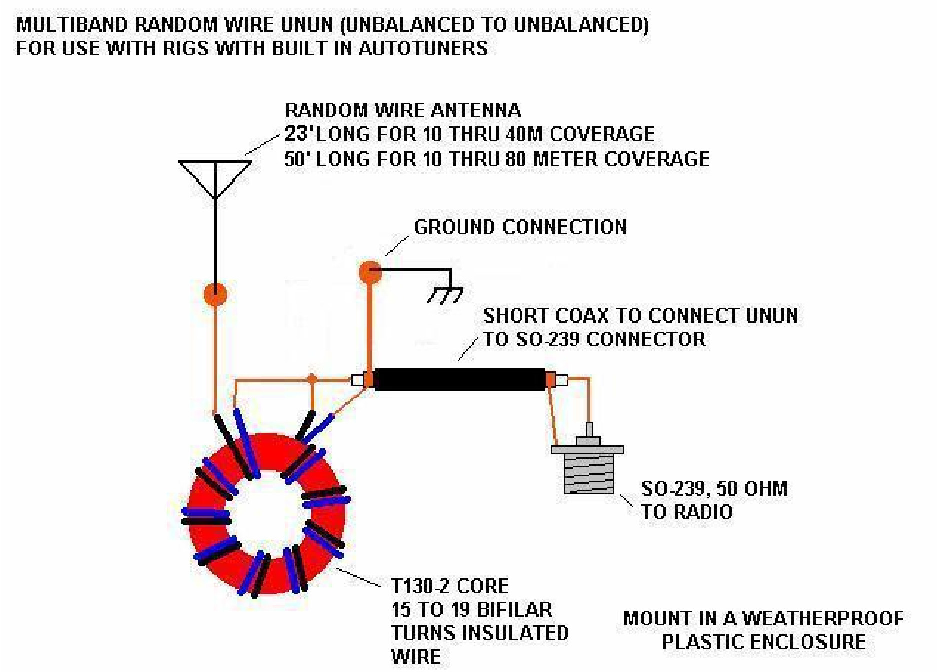
G0KYA has also written lots of interesting articles about antennas and several pieces about using a 9:1 unun and a length of wire. He found that a wire length of 19.8 metres offered a good compromise for a multi band aerial. Read G0KYA's blog here: http://g0kya.blogspot.com/search/label/antennas

More : http://g0kya.blogspot.co.uk/search/label/antennas

Interestingly 2W0SAK of Snowdonia Radio Company recommended an antenna wire length of 7.13 metres with their 9:1 unun - or for better efficiency a wire that is 19.8 metres long which would be run out horizontally. Both the 7.13 m and 19.8 metre lengths should cover the 80m to 10m bands.

Freq Coverage	Wire Length	or try
7 - 29 (50) MHz	2.74 m	6 m
3.5 - 29 (50) Mhz	7.13 m	9.8 m or 16.1 m
3.5 - 29 (50) MHz	19.8 m	21.9 m or 26.8 m
1.8 - 29 MHz	29.0 m	29.9 m
1.8 - 29 (50) MHz	39.6 m	36.6 m

High Quality Baluns and UnUns Available From www.gwhip.co.uk - either boxed and ready to use or just the core and quality windings suitable to put into own box or project.

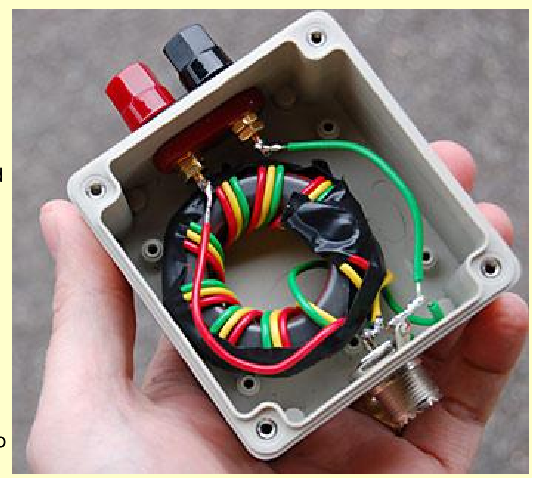


Above is a neat design for an "Untenna" KC8AON - Link: http://www.angelfire.com/electronic2/qrp/unun.html

For a jack of all trades try a high quality GWhip "Widebander Antenna"

G0KYA writes a very useful piece in his blog:

http://g0kya.blogspot.com/search/label/antennas



In the next round of tests I used the same 9:1 Un-Un wound using PVC covered cable and a T200-2 toroid. Note in the photograph that the PVC tape is only used to keep the turns neatly arranged.

If you want to build your own follow these instructions:

Building a 9:1 unun
To understand how to construct an unun lets build a 9:1 version. You will need a T-200 (red) toroid and three pieces of wire, each 24 inches (60cm) long . It will also help if you a small plastic box with an SO239 socket mounted at one end and with two wing nuts or mounting posts at the other. In the UK you can buy a small plastic box from Maplin which is watertight with a rubber seal, yet inexpensive.
It will help if the wires are different colours, although that isn't critical if you have a multimeter available. It just makes it a lot easier to follow these instructions.
For the sake of this explanation I'll assume that you are using green, red and black pieces of wire.
Put the three pieces of wire together and wind them carefully onto the T130-2 toroid. Place the wires (left to right) green-black-red, and wrap nine turns on to the toroid.
Try not to let the wires overlap.
You should end up with a toroid with three wires extending from the left winding and three wires extending from the right.
Now twist and solder the left black wire with the right red wire. This can be covered with PVC tape once complete.
Now twist the left green wire with the right black wire. Strip the ends of the two wires, twist and solder them together leaving the length about 2” long from the toroid.
Finally trim and strip the remaining right green wire and solder another 5” piece of green solid wire to it.
Now take the left green wire and right black wires that you twisted together and connect them to the centre pin of the SO239 socket – this is the input side and will connect to your radio via a length of coax.
One of the green wires is now soldered to the ground connection of the SO239 socket. The other end of the wire you soldered on (which is connected to it) becomes the earth connection for the unun and typically goes to a ground stake and ground radials.
This leaves the remaining red wire which connects to the other wingnut and will become the connection for the antenna.
If you are worried about the wires unravelling you can either use PVC tape to hold them in place or plastic cable ties.
So how do we use an unun? Lets look at a typical example.

This time I erected a 10m high fishing pole and attached a 65ft quarter wave antenna for 80m in an inverted L fashion. That is, 10m up and then 9.8m out to the nearby summerhouse.

This was arranged away from the house and fed with 12m of RG8 coax, a single earth stake and two 20ft radials at the feed point..

Here are the SWR readings at the end of the coax:
3.5MHz – SWR 3:1
3.65MHz – SWR 4.2
3.8MHz – SWR 5.9
7.10MHz - SWR 13.6:1
10.1MHz – SWR 2.5:1
14.2MHz – SWR 3.3:1

18.14MHz – SWR 1.8:1
21.2MHz – SWR 2.4:1
24.9MHz – SWR 1.9:1
28.5MHz – SWR 1.2:1

From this you can see that by shortening the wire to 65ft from the original 85ft you gain 80m, but lose 40m. The rig (FT2000) would quite happily tune seven bands with its internal ATU. Here are the quick comparison results against my 80m Windom and parallel-fed dipoles in the loft for 40m, 20m, 17, and 10m.

80m
Not as good around the UK as the Windom - probably due to the maximum current being in the vertical section. Modelling shows the antenna to be down about 10dB on a low dipole.
30m
Lithuania similar. Other EU and Italy similar. Bulgaria down 2 S points
17m
Similar – inverted L has slight edge at times. Slightly noisier
15m
Better than Windom by about 1 S point.
10m
Much better than Windom, dipole and mag loop around Europe via Es, by about 2 S points. Slightly more noise (+ 1 S point).

From this I can see that I need to do more tests, especially on 20m, but for an all-in cost for the antenna of about £15-£20 it shows promise. If you have a tree then the up and out idea with a 65ft wire looks quite good. A way to get 40m back would be to put a 40m trap in the wire at the 10m mark. If you don't fancy making your own UnUn you can buy the whole antenna from the Snowdonia Radio Company for £35 inc P&P – see http://www.snowdonia-radio-company.co.uk/srcproducts.html [From a collection of excellent articles from G0KYA] Link to SRC: http://www.snowdonia-radio-company.co.uk

GWhip Antennas, and ProWhip Antennas all supply this type of antenna as a commercial item.

CONCLUSIONS?

Arguably the most effective, simplest and, indeed, cheapest way to attain multi-band operation is by using a full size resonant dipole for each band of interest - perhaps having a couple suspended at any one time and swapping aerials when other bands are needed.

As mentioned in the introduction this is a little inconvenient which is why the holy grail of so many amateurs is one antenna that that will do everything - perfectly. As we have seen such an aerial does not exist, and never will due to those pesky laws of physics. Compromises will always have to be made; compromises of efficiency, size, number of bands and bandwidth per band etc - nevertheless there are enough options available to be able to choose a configuration of antenna or antennas that should be able to make the best use of precious transmitter power for a particular circumstance.

My two key criteria are that the antenna should be truly resonant on the band(s) of interest and that the radiating elements should be as near to full size as possible, relative to the wavelength(s) being used, to ensure the best possible efficiency (i.e. lowest loss of power). This means full size quarter wave vertical or full size half wavelength long trapped dipole.

I don't especially like aerials that are shortened by using a loading coil, but accept that such an arrangement is sometimes necessary for the longer wavelength bands. Top Band is a real problem in average size gardens. Where the is a coil, a trap, or transformer there will be some loss or reduced efficiency introduced into the antenna system. I do find that using a trap is an excellent compromise - the 80m / 40m Inverted L and the 20m / 10m trapped dipole work especially well. If I could not use the Inverted L, my next favourite option is the Loop or a fan (Parallel) dipole.

All the pros and cons have to be weighed up to find the best compromise for particular operating circumstances. I hope that this page has given new operators some ideas to take away and mull over, but remember those words from Joe Tyburczy WB1GFH that this page started with:

"When you put up your antenna is also crucial. I must mention here the importance of what many early hams called "antenna weather". That is, snow, sleet, freezing rain, or combination of all the above. It has been proven time and time again that any antenna installed in conditions better than abysmal will not function worth a darn. Or, put another way, it takes bad weather to put up a decent antenna. Dark and cold New England winter days are ideal for this activity. Any antenna erected on such a day will inevitably produce miracles."

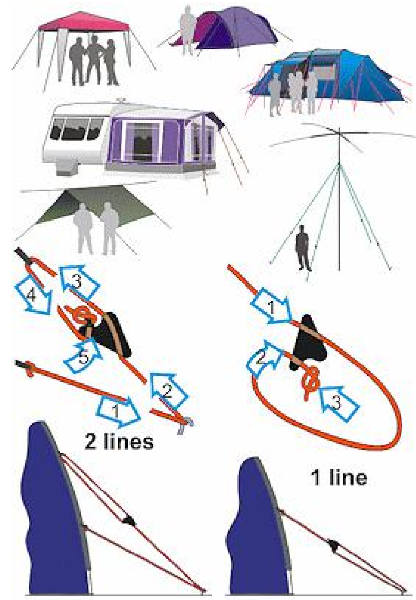
Some Further Reading:

Understanding Antennas For The Non-Technical Ham
A Book By Jim Abercrombie, N4JA
basicantennas.pdf

More Antenna Ideas by other amateurs (.doc)

ARRL document Multi Band Dipoles Compared (.pdf)

Useful Aerial Rigging Accessories



Line-Lok guy runners from ClamCleats - fantastic for guying antenna masts quickly and successfully
http://www.cleats.co.uk http://www.clamcleat.com

Reusable Nylon Hose Clip / Reusable Circular Clamps
Useful for securing telescopic fibreglass poles - e.g. holding each section in place in windy weather or to use as a guying ring (spider)
(Herbie Clips) (Kaf-flex Nylon Clamps)
http://www.malpasonline.co.uk
http://news.thomasnet.com
http://www.hclfasteners.co.uk/acatalog/Herbie-Clip.html
http://www.cheapham.com/products/S9V31-Replacement-Clamps.html
http://rotocon.homestead.com/shoponline2.html

OTHER THINGS THAT MAY BE NEEDED:

POLE(S) Aluminium, fibreglass or wood ; POLE TO POLE CLAMPS ; MET POST(S) ; NYLON CORD or PARA CORD ; SPIDERS / 3 or 4 WAY GUY RINGS ; PULLEYS ; SNAP HOOKS ; DEE SHACKELS ; GROUND STAKES for anchoring guy ropes ; DOG BONE or EGG INSULATORS ; DIPOLE CENTRES ; EARTHING STAKE ; V BOLTS ; ROPE GRIPS ; THIMBLES ; SLEEVE JOINER(S) ; T&K BRACKETS ; TRIPOD or other GROUND MOUNTING HARDWARE ; STAINLESS STEEL M6 Nuts Bolts and Washers ; SPADE and / LUG TERMINALS ; SELF AMALGAMATING TAPE ; HEATSHRINK ; WEATHERPROOFING SEALANT ; STAINLESS STEEL JUBILEE CLIPS.

TRIMMING AERIALS

Antenna Trimming Chart

This following information below could be very useful indeed when constructing aerials and is compiled by DX Zone / Radio Works from the web page at: http://www.dxzone.com/cgi-bin/dir/jump2.cgi?ID=13444

Use this chart as an aid in trimming the length of your antenna. It gives you an idea of the change in wire length needed to move antenna resonance a specific number of KHz.

* Dimensions are for each leg of a half-wave dipole
* For quarter-wave antennas (i.e. verticals) use the dimensions directly from this chart
* Full-wavelength antennas (loops) - multiply the chart dimensions by four (4) and change the overall length of the antenna by that amount.

Lengths are estimates. Many factors will affect their exact value.

To move	80/75 m	40 m	20 m	15 m	10 m
-500 kHz	+8' 4"	+2'	+8"	+3"	+1.5"
-400 kHz	+6' 8"	+1' 9"	+6.5"	+2.5"	+1.25'
-300 kHz	+5'	+1' 4"	+5"	+1.75"	+1"
-200 kHz	+3' 4"	+10"	+3.25"	+1.25	+5/8"
-100 kHz	+1' 7"	+5"	+1.5"	+1/2"	+3/8
00 kHz	0	0	0	0	0
+100 kHz	-1' 7"	-5"	-1.5"	-1/2"	-3/8"
+200 kHz	-3' 4"	-10"	-3.25"	-1.25	-5/8"
+300 kHz	-5'	-1' 4"	-5"	-1.75"	-1"
+400 kHz	-6' 8"	-1' 9"	-6.5"	-2.5"	-1.25'
+500 kHz	-8' 4"	-2'	-8"	-3"	-1.5"

Example:

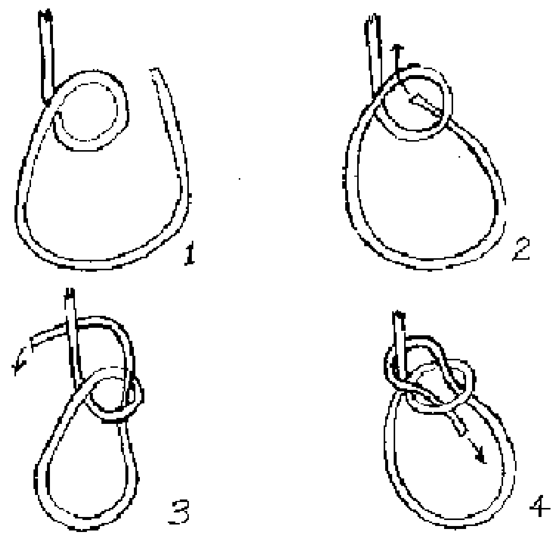
You have measured the SWR of your 40 meter dipole at various frequencies across the band. You have determined that the SWR is lowest at 7.00 MHz. You actually want the lowest SWR to occur up in the sideband portion of the band, so you need to move resonance up in frequency about 200 KHz.

According to the chart, to move +200 KHz on 40 meters, you will have to shorten each leg of the dipole 10" (-10"). The overall length of the antenna is shortened a total of 20 inches.

Lengthening or shortening the antenna is done at the end insulators. To shorten the antenna, unwind the antenna wire as it wraps around itself at the end insulator. Move the insulator several inches toward the center of the antenna. Re wrap the antenna wire to secure the end insulator. Do not cut the wire. Wrap it back around the antenna wire. You may need to increase the antenna later. [From Radio Works / DXZone]

KNOTS FOR SECURING WIRE ANTENNAS

I have found the Bowline to be one of the most useful, it is strong and easy to tie. A Bowline will not slip in any circumstances and, usefully, the more load that is put on it, the tighter it gets.



The Bowline Knot

A Bowline can be used to tie two ropes together and should be used to tie a support rope to a pulley, dipole centre and other antenna items.

It's important to use the correct knot for the job when fixing up wire antennas. I find the Bowline is a very useful for fixing end, egg and dog-bone insulators to the ends of the wire and/or ropes.

The Buntline Hitch is an excellent knot as is the Round Turn & Two Hitches, Anchor Bend (Anchor Hitch) knots which are very good for tying a rope to a pole or a mast.

The Bowline is most useful for fixing end, egg and dog-bone insulators to the ends of the wire and/or ropes.

A Double Sheet Bend can join two pieces of rope together - even if they are of unequal size.

'Animated Knots' will show you how to do them. Visit http://www.animatedknots.com

More websites with knot information : http://www.netknots.com/ http://www.southee.com/Knots/Index.htm

The correct knot will ensure that the antenna will be as strong as possible.

LINKS

Understanding Antennas For The Non-Technical Ham - A Book By Jim Abercrombie, N4JA :
PDF Book: http://www.hamuniverse.com/basicantennas.pdf
HTML page: http://www.hamuniverse.com/n4jaantennabook.html

G4ILO - Stealth Antennas: http://www.g4ilo.com/stealth.html

All Band Doublet Antenna by M0MTJ :
http://www.mds975.co.uk/Content/amateur_radio_antennas_06.html#All_Band_Doublet_Antenna

All Band Doublet Antenna : http://www.hamuniverse.com/hfdoublet.html

All Band Doublet Antenna by AI4JI : http://www.ai4ji.com/Projects/antennas/doublet.htm

Amateur Radio MØMTJ

MDS975.co.uk HOME PAGE

AERIALS (ANTENNAS) 1

Antennas 2 | Antennas 3 | Antennas 4 | Antennas 5 | Antennas 6 | Antennas 7

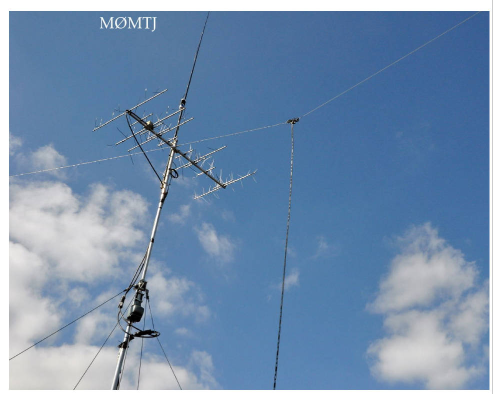
"Success is 90% antenna and 10% rig. Hobby is 90% listening 10% transmitting" *- MM0HDW.*

AERIALS used by MØMTJ

This page shows some the antennas that I have used over the course of time.

Index To Other Antenna Pages:

2014 : Current Set Up - as at September 2014:



The Summer of 2014 has seen a few changes of aerials. The 80m/40m Inverted L was removed and replaced with a newly constructed Doublet Antenna fed with ladder line via a 4:1 G-Whip current balun and an LDG "ATU". The Tecadi support pole originally used for the Inverted L is now used to support one end of the Doublet. You have probably read this elsewhere, but I can confirm that the All Band Doublet (fed with ladder line *not coax*) is a superb all round HF aerial. Highly recommended.

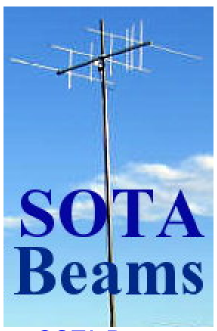
The SGC-230 Automatic Antenna Coupler was moved from the original feedpoint of the Inverted L antenna to the second feed-point on the other side of the garden. This now feeds a sloping wire of approximately 20 meters length to ensure that the 80 Meter Band and Top Band (160 meters) remain available. This antenna will also 'tune' on most other bands, so remains a very useful second antenna, though the All Band Doublet is often considerably better, particularly on the higher frequencies. The old SGC-230 was also faulty and I replaced it with a new CG-3000 auto coupler from Martin Lynch and Sons.

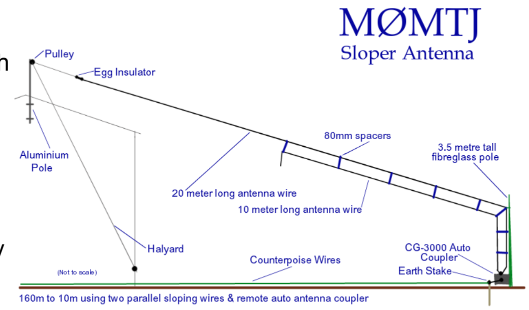
The J-Pole for 4 Meters (70 MHz) was removed since it wasn't used much, being only connected to a 4m hand-held radio - it seemed to be a waste of precious antenna space. This was replaced with a newly constructed Half Wave "CFR" Antenna (Coaxial Dipole) for 6 Meters (50 MHz) connected to the main HF radio via Westflex 103 coax. The DK7ZB dual band Yagi antenna remains, as does the 10m / 6m Fan Dipole in the loft space. Also remaining in place at the apex of the house is the home-brew 2m / 70cm "CFR" Antenna (Coaxial Dipole) for VHF/UHF FM operation - this has been a particularly effective antenna.

To sumarise:

1) A 20 meter long doublet antenna fed with balanced ladder line for 40 meters to 6 meters. The 'old timers' really knew their stuff, this an excellent all round antenna that is easy and cheap to make and should be quite easy to accommodate and install. See photograph below and read more here

2) A Sloper Antenna consisting of two parallel wires - one wire being 20 meters long with a second parallel wire





that is 10 meters in length. The first 2.5 meters (approx) of wire runs vertically up a non metallic post, then the remainder slopes back towards the house being finished off with an insulator which is attached to a Para-Cord lanyard that runs through a pulley on a pole at the apex of the roof. The antenna wire can therefore easily be let down for maintenance or adjustment whenever required. For lowest possible loss, the antenna is fed via a GC3000 automatic antenna coupler located at the bottom of the garden. The antenna is primarily for lower HF bands including 160 meters, 80 meters and and 40 meters, but it also works very well on some higher bands. The GC3000 itself is mounted in a waterproof IP56 rated enclosure near ground level at the bottom of the garden. Grounding is achieved from two 4 foot long copper ground stakes and several radial grounding wires.

Read more about the Sloper Antenna and the CG3000 here.

3) A 'home-brew' omnidirectional, vertical dual band, end fed antenna for 2 metres and 70cm. This is of the Controlled Feeder Radiation design (CFR) by VK2ZOI; effectively an end fed half wave dipole on 2m with an aluminium sleeve dipole section to achieve 70cms with a few extra dB's of gain. It is mounted on an aluminium mast. It's feed-point is about 11 metres a.g.l. read more here

4) A DK7ZB design dual band Yagi antenna, with 5 elements for 2 metres and 8 elements for 70cms, mounted horizontally for SSB. A lightweight antenna rotator is employed and uses a push-up telescopic mast. Height above ground level is again approximately 7 metres. The DK7ZB is an excellent twin band Yagi antenna. read more here

5) A Half Wave End Fed / Controlled Feeder Radiation (CFR) antenna for 6 meters / 50 MHz. Supported by a 3 meter long telescopic fibreglass fishing pole attached to the top of the aluminium push up mast that supports the DK7ZB dual band yagi and rotator.

6) Dual Band Fan Dipole, made from thick loudspeaker wire, mounted horizontally in the loft space for 10 meters an 6 metres. Cheap & quite effective.

Other Options that can be deployed on an 'as required basis' :

7) A half wave Wire J-Pole fixed to a telescopic fibreglass fishing pole for 10m. Cheap and effective. more about J-Poles here and also here on Antenna page 5

8) Compact Loaded Top Band Antenna, based on a design idea by Stuart Craigen G4GTX more

9 & 10) G Whip End Fed Zepps (EFZ's) for either 20m, 15m or 17m or the G-Whip "WideBander" which is an 'UnTenna' style antenna that can be used for 20m through to 10m using good quality G Whip 9:1 UnUn; useful additions for antenna flexibility. more

11) N9TAX Dual Band Slim Jim (J-Pole) antenna mounted in the loft as a back-up antenna for 2m and 70cms. Very good. more

12) Delta Loop Antenna - 16 metre loop of wire in triangular Delta shape, hung from the top of the pole supporting the inverted L antenna and fed via RG213 coaxial cable via a 4:1 balun. The loop is really a single band antenna cut for one wavelength on the band of interest, however it also can be pressed into service for some higher bands - a good, cheap and easy to install aerial; Often works better than the inverted L on the higher bands, but on 10 metres the tuned 10 metre dipole in the loft is sometimes better. more

Knots: Knots for securing wire aerials and other things more here

H.F. ANTENNAS used by M0MTJ

All Band Doublet Antenna

The Doublet Antenna consists of two 10 meter long top wires to form the 20 meter long 'dipole' section. The centre is fed with Ladder Line rather than coaxial cable. A dipole fed with coaxial cable is essentially a single band (mono band) antenna. Feeding such an aerial with ladder line, or open wire twin feeder makes a much more effective multi-band antenna.

The ladder line runs down to a high efficiency 4:1 Current Balun (G-Whip) which is connected to an LDG AT-200 automatic antenna matching unit via a very short RG213 patch lead to ensure lowest losses. The Antenna tuner and balun are housed in a box which is itself contained in a small garden shed to protect it from the weather. The LDG antenna matching unit is then connected back to the 'shack' via a run of RG-213 coaxial cable. Read more

about the All Band Doublet Antenna here.

A view of part of the MØMTJ All Band Doublet Antenna
Read more here

ANTENNAS FOR VHF and UHF - 2 m & 70 cms

The main antennas are as follows:

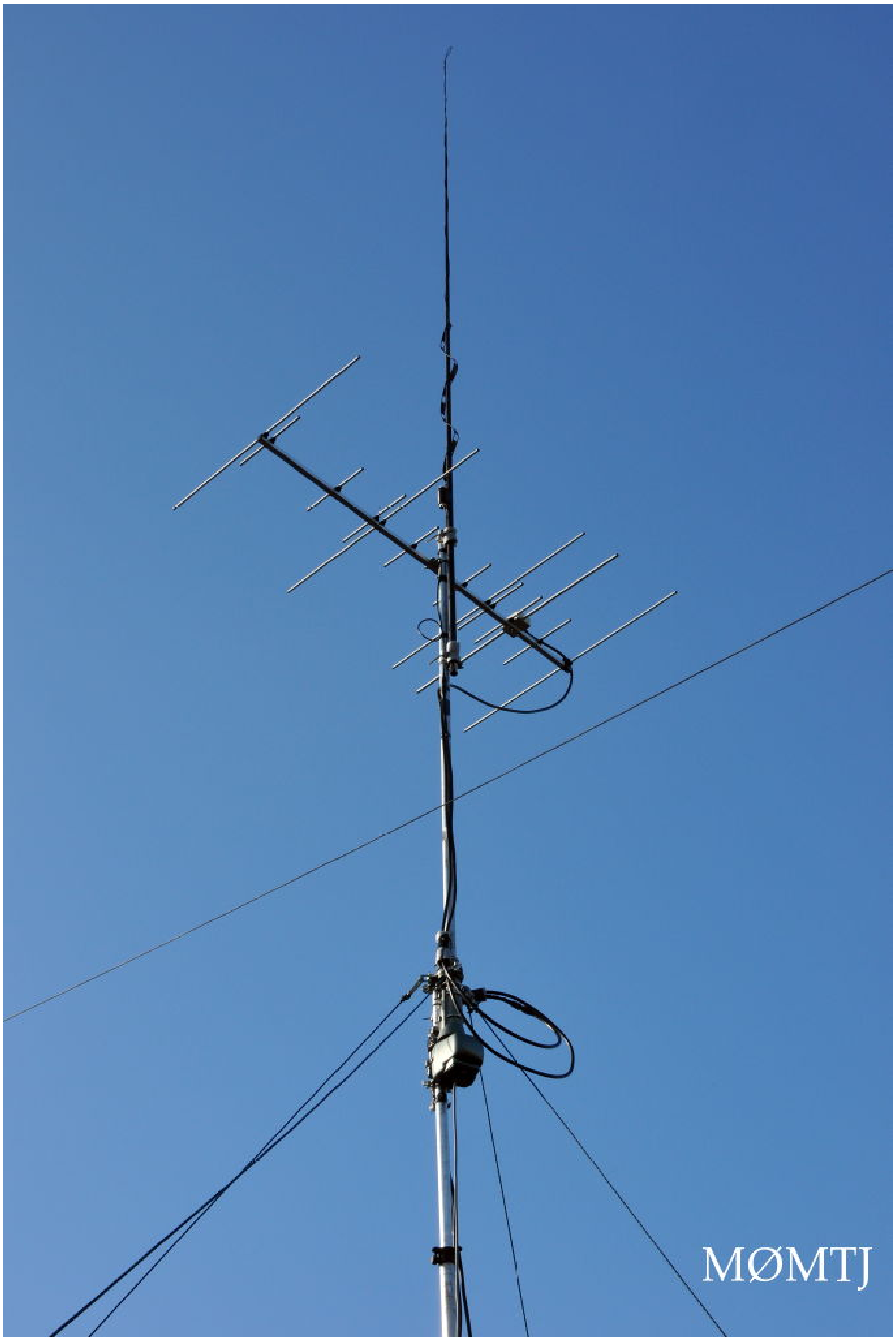
Home-Brew dual band end (physically end fed) half wave "Coaxial Dipole" for 2m & 70cm

For 2m and 70cm FM I use a mounted on a lightweight aluminium telescopic pole on the apex of the hose. The base of the antenna (the bottom of the radiating element) is approximately 11 metres above ground level. This antenna is based on the Controlled Feeder Radiation principle (CFR) and is described by VK2ZOI. Read more about its construction here. Also seen in the photograph below are the ropes that support the H.F. wire aerials.

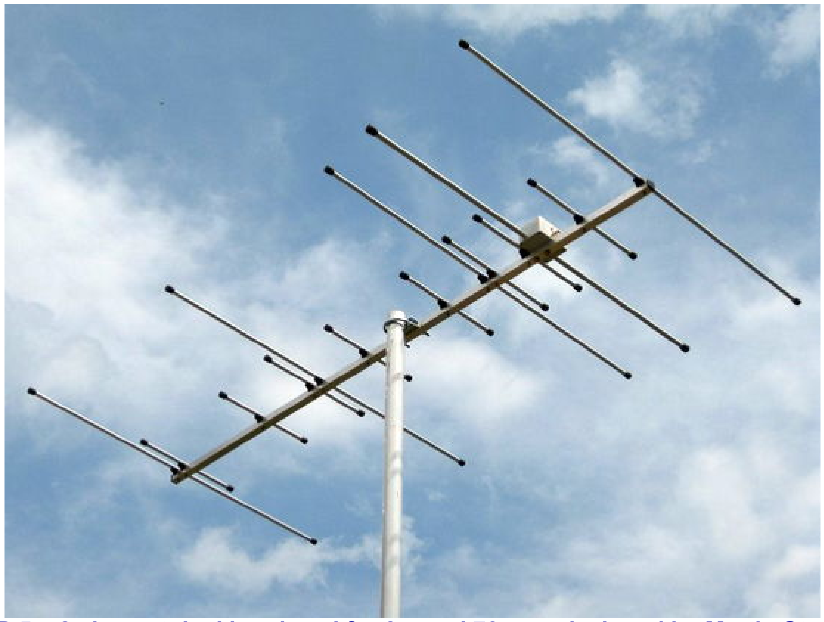
Home brew dual band vertical antenna for 2 metres and 70 cms
[Read more about its construction here]

Dual Band Yagi for 2m & 70cm

For 2 metres and 70cms SSB there is a horizontal DK7ZB design dual band Yagi antenna. This has 5 elements for 2 metres and 8 elements for 70 cms. A lightweight antenna rotator is employed and uses the same push-up telescopic mast that the Home-Brew 70MHz J-Pole is mounted on. Height above ground level is again approximately 7 metres. The DK7ZB is an excellent twin band Yagi antenna**.**



Push up aluminium mast with rotator, 2m / 70cm DK7ZB Yagi and a 4m J-Pole at the top



The DK7ZB 5 + 8 element dual band yagi for 2m and 70 cm - designed by Martin Steyer DK7ZB
Available from Arthur M0PLK (SQ2PLK) at Ham Radio Shop:
http://stores.ebay.co.uk/urbasket-eu
http://ham-radio.urbasket.eu
Also available from VPA SYSTEMS by SQ9VPA http://www.vpa-systems.pl
Kits available from NUXCOM.de : http://shop.nuxcom.de

2 Meter J-Pole Antenna for the garden shed - and other J-Pole antennas for 6 metres and 10 metres :

While experimenting with antennas in the garden in the summer of 2012 I thought that it would be good to have a hand-held radio in the shed to do some monitoring and make a few contacts. To improve upon the performance of the 'rubber duck' antenna I quickly made a J-Pole antenna for the 2 metre band.

It is made from a 47cm length of 450 ohm Wireman ladder line as the 1/4 wave matching section, plus a 97cm length of stranded wire as the 1/2 wave radiator. It is fed with 3 metres of Mil spec RG58 c/u coaxial cable that is soldered to the 1/4 wave matching section's impedance matching point at 3.5 cm from the bottom. The coax feeder is wound around some PVC tube to form a choke. The completed antenna is taped to a 2.2 metre long fibreglass fishing pole that I purchased from Poundland (for £1.00). It took about 20 minutes to make followed by some testing and adjustment with the antenna analyser. The fishing pole is lashed to the shed with some cable ties.

This simple antenna works pretty well, but being so low down signal strengths are not huge, but it's pleasing to get on the air with something so simple and cheap!

Find out how easy it is to construct J-Pole Antennas here

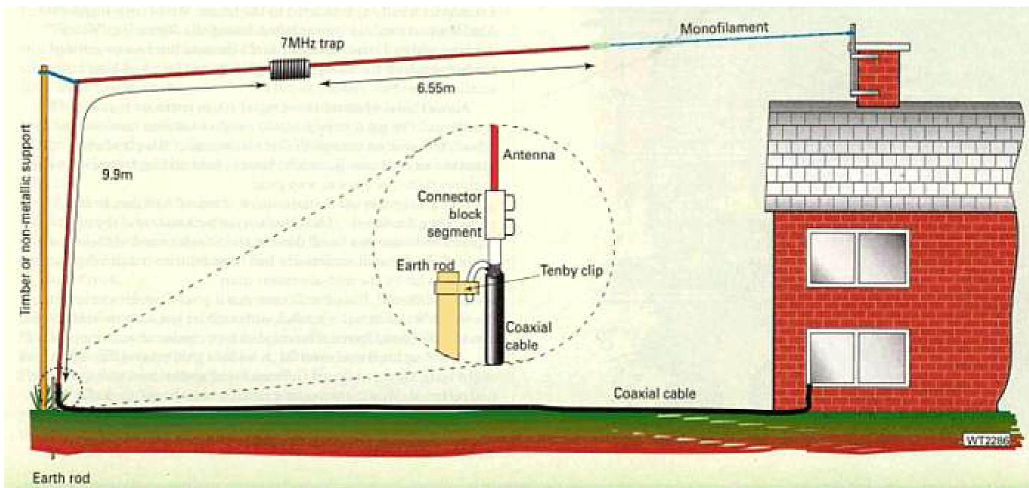
Now, if it was at the top of my 10 metre long fishing pole. . . . . (!)

The Shed Antenna - a 2m J-Pole by M0MTJ
Note the simple choke balun at its base made by winding 8 turns
of the coaxial cable around a small off cut of white PVC water pipe.
[Find out how easy it is to construct J-Pole Antennas here]

The feed point of a J-Pole antenna made from Wireman 450 ohm ladder line.
More here

More Antennas . . .

Inverted L Antenna for 80m and 40m (and some other HF Bands from 80m to 10m)



The basic layout of the Inverted L Antenna (Practical Wireless)

The first antenna that I installed was for HF. I decided on an Inverted L that incorporates a 7MHz trap so that it can be used on both 7MHz (40 metres) and 3.5 MHz (80 metres).

The design of this Inverted L is well known and a good design has been published previously in Practical Wireless by Len Paget GM0ONX. It is based on one half of the famous W3DZZ trapped dipole antenna.

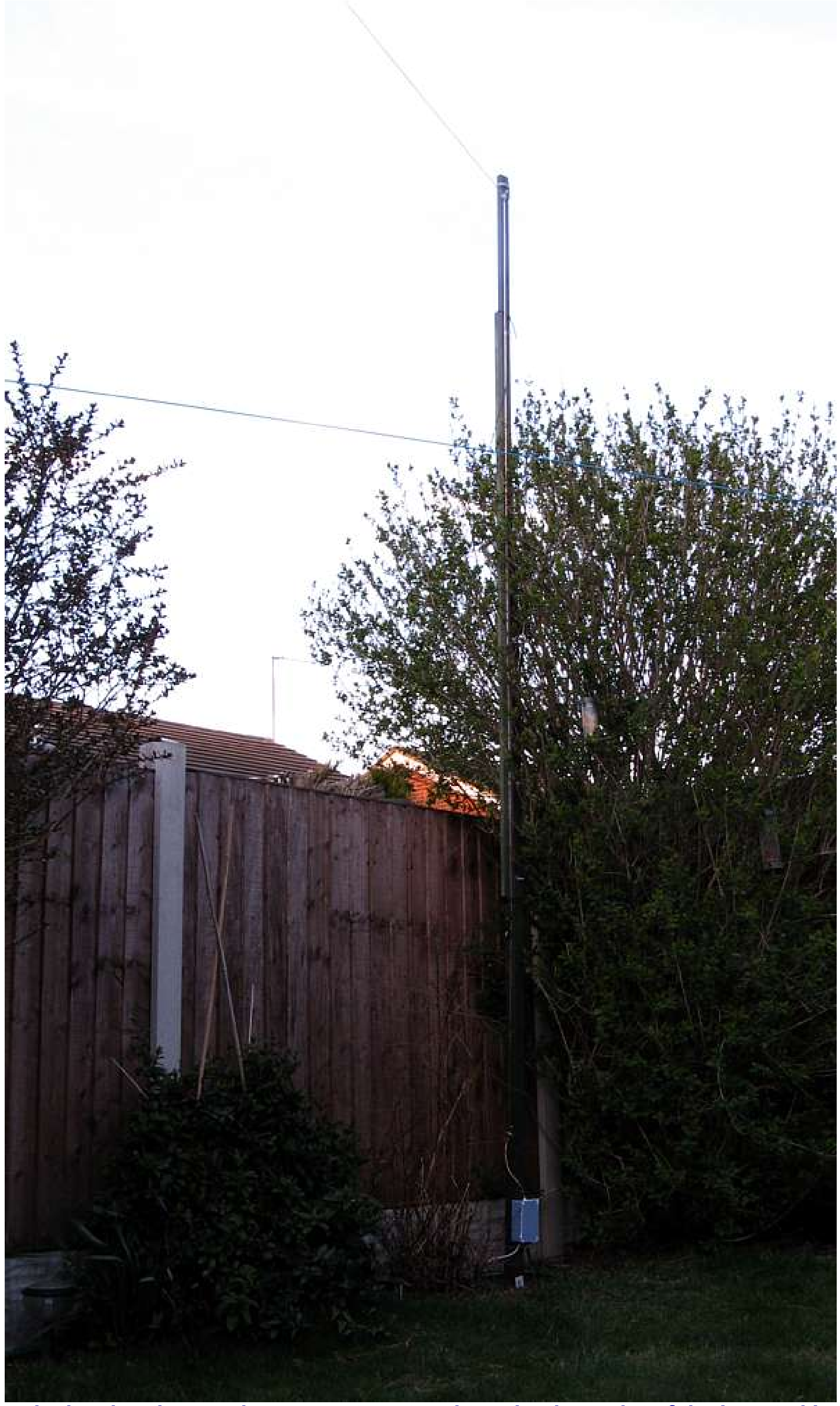
It can be made entirely from scratch as a DIY project, or the 7MHz trap could be purchased commercially as a ready made item, or whole antenna can bought as a complete kit from Tony Nailer, G4CFY, at Spectrum Communications. I opted to buy the 7MHz trap from Spectrum Communications, as I already had most of the other materials required - rope, egg insulator, plastic box, and some good aerial wire. The Spectrum Communications trap is solid and well made and 'potted' to protect against the elements.

This antenna is tuned for 40 metres and 80 metres, but the VSWR is acceptable on several other bands being in the region of 2:1 to 5:1. The designer anticipated that this antenna would be usable on five of the H.F. bands between 80m and 10m.

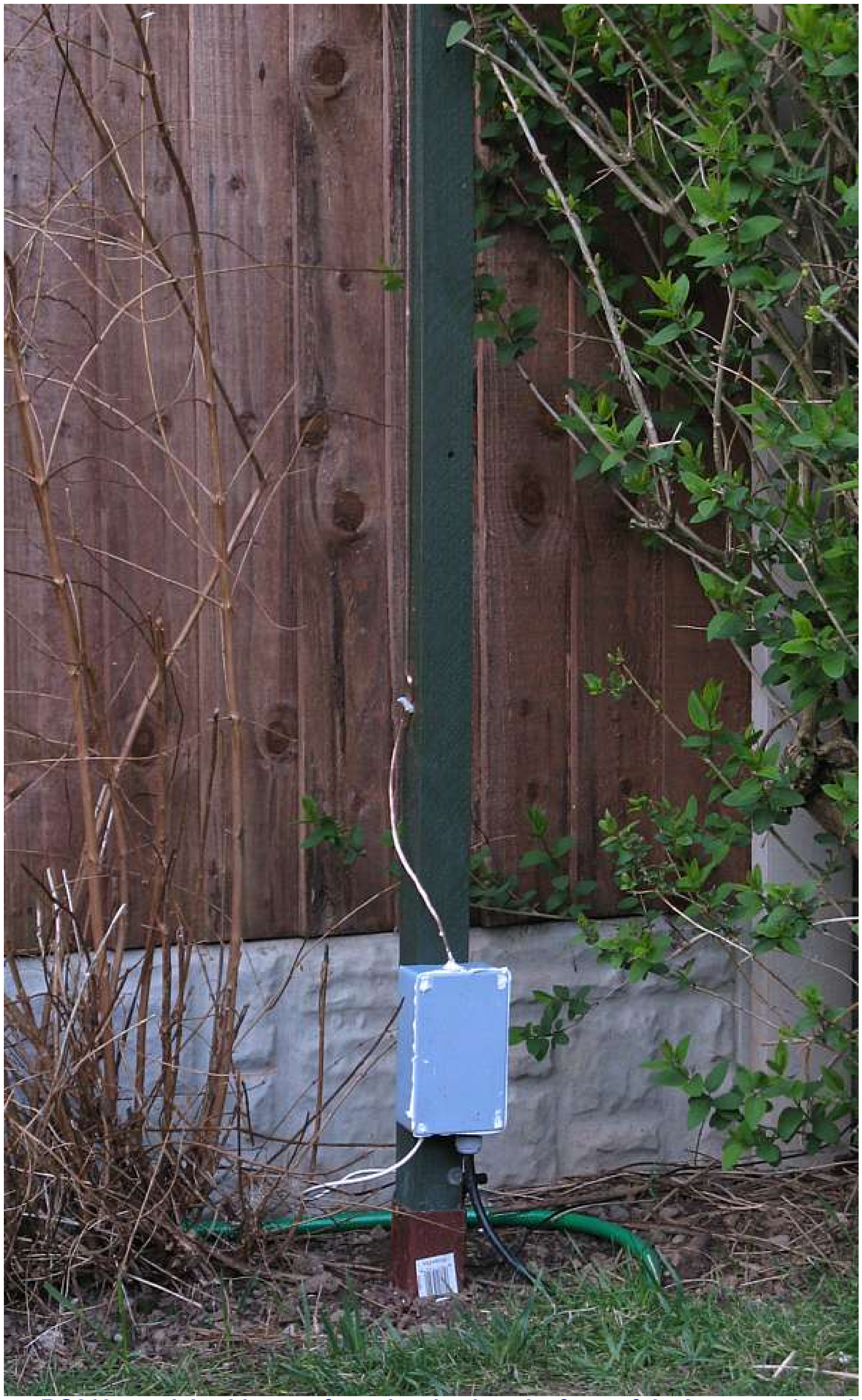
I have found that with the use of the Antenna Tuning Unit it can be used on all of the H.F. bands. However the polar radiation pattern may very well be less predictable on bands other than the intended 40 and 80 metres, and it may well be less effective than might be desirable - but it does work!

The antenna is in the back garden, while the shack (radio room) is in a bedroom at the front of the house. It is fed by a 30 metre length of RG213 coaxial cable (it is not possible to use twin feeder for this type of antenna as the Inverted L is an UN-Balanced aerial, whereas twin feeder is balanced). With this length of cable I estimate the loss in the feeder alone to be about 1dB at 7MHz. The feed point of the aerial is located at the base of a 16 foot high wooden pole near the bottom of the garden. The horizontal top wire returns to a fibreglass pole installed at the apex of the roof.

+ 17 + 160: I have since added a separate sloping wire element for the 17 Metre Band and a switchable loading coil for Top Band - see notes below...



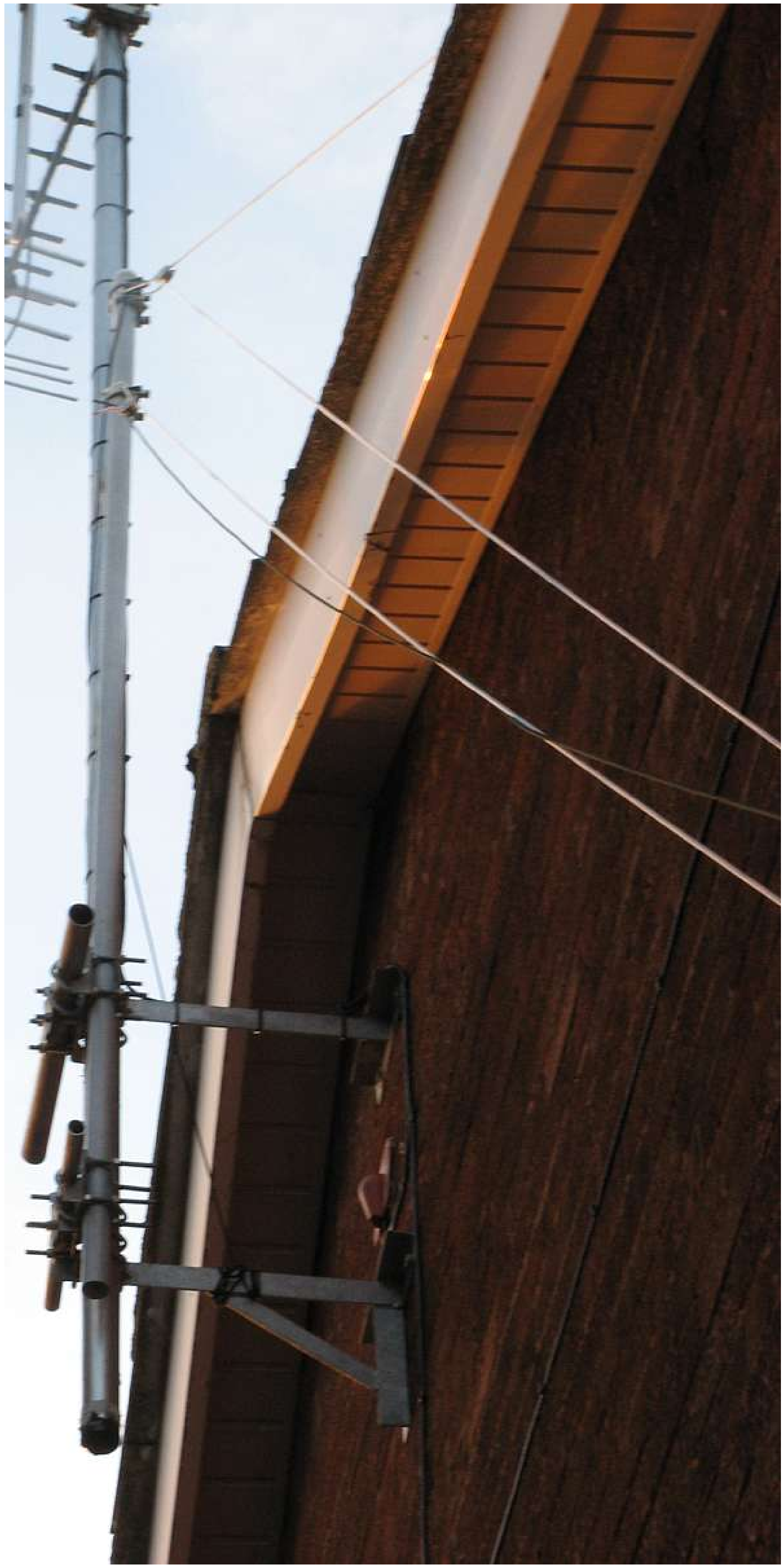
Photograph showing the wooden support post and termination point of the Inverted L antenna The post is coloured green with green fence treatment to mast it somewhat. I have also placed it near the bush to provide further camouflage.



The low loss RG213 coaxial cable runs from the shack at the front of the house up into the loft and exits into the back garden down the rear wall, through some garden hose to offer some protection along the flower bed to the bottom of the garden where it is connected to the base of the Inverted L antenna.

The suspended Inverted L aerial with 7 MHz trap.

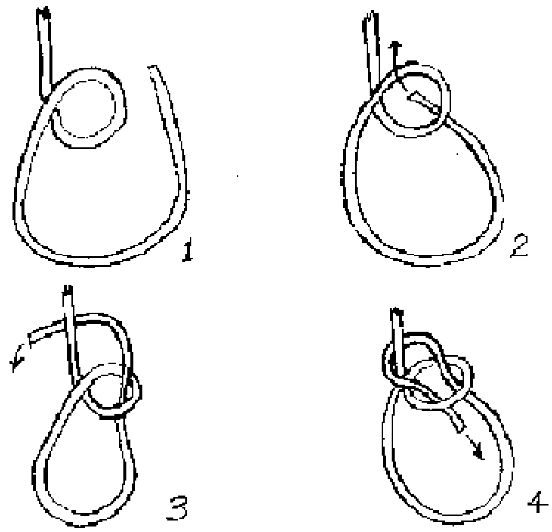
The Inverted L antenna - lower section now nicely camouflaged. The wooden support post is some 6 metres long.



The photograph above shows the Dacron ropes supporting the ends of the Inverted L and Dipole antennas are held in place at the top of the fibreglass support mast by a pulley - one pulley for each support rope. This facilitates rapid lowering of either antenna for adjustment or replacement. This photograph also shows a second rope and pulley system that was originally used to support the 20m dipole and is now used for the top band inverted L wire

aerial.

I needed a good reliable knot for securing ropes when installing wire antennas and have found the Bowline to be one of the most useful, it is strong and easy to tie. A Bowline will not slip in any circumstances and, usefully, the more load that is put on it, the tighter it gets.



The Bowline Knot

A Bowline can be used to tie two ropes together and should be used to tie a support rope to a pulley, dipole centre and other antenna items.

It's important to use the correct knot for the job when fixing up wire antennas. I find the Bowline is a very useful for fixing end, egg and dog-bone insulators to the ends of the wire and/or ropes. The Round Turn & Two Hitches, Anchor Bend (Anchor Hitch) and Buntline Hitch knots are very good for tying a rope to a pole or a mast. A Double Sheet Bend can join two pieces of rope together - even if they are of unequal size. 'Animated Knots' will show you how to do them: http://www.animatedknots.com

Photo showing pulley fixed to the top of the wooden support post and the aerial support rope that it holds in place.

The Spectrum Communications Trap

View of trap showing that the joints have been thoroughly sealed against the weather with self amalgamating tape and silicone sealant.

Just for good measure I sealed the internal side of the machine screw that forms the connection terminal against the weather with Watson sealant putty.

Adding Top Band to the 80 / 40 metre Inverted L Antenna:

Due to an aborted house move in 2010 I had removed all the antennas. While re-establishing the aerials in 2011, and considering space limitations, I decided to experiment with adding a loading coil to the 40m / 80m Inverted L aerial. The loading coil has a link wire to short it out of circuit when using the aerial for 80 metres and 40 metres. The link wire is removed when Top Band is required.

I also took the opportunity to replace the original wooden post with a strong 6 metre tall fibreglass pole.

The coil consists of approximately 37 turns of PVC covered antenna wire wound on a short piece of PVC pipe. Once the required points of resonance were set for 40 metres and 80 metres, the link wire was removed and number of turns on the coil were adjusted until the required point of resonance was found on the 160 metre band. I set it to around 1900 kHz - the bandwidth is quite narrow.

Once the work was done, the joints and connections were sealed with either Liquid Electrical Tape or self amalgamating tape, then the connecting box, V bolts and white PVC pipe were sprayed with green paint to help it all blend in with the surroundings a little better.

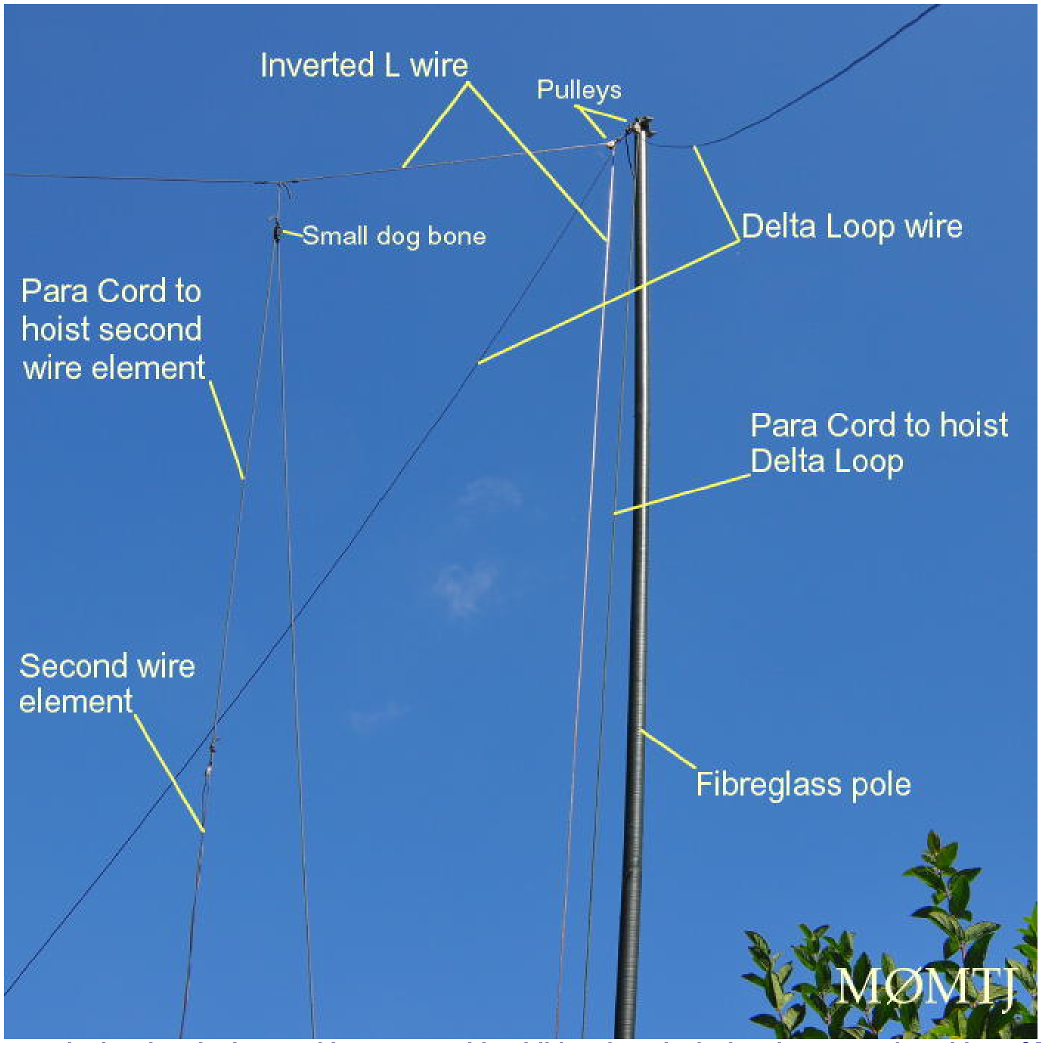
Adding the 17 Metre (18 MHz) Band to the 80 / 40 metre Inverted L Antenna:

The Inverted L is not too good for the 'WARC' bands so to obtain better performance on the 17 Metre band I added a single slightly sloping wire element cut for that band. The lower end of the wire is permanently connected to the feed terminal on the junction box, the other end is tied to a small dog bone insulator. This dog bone is then supported by a length of thin para-cord which is tied to the horizontal wire of the main Inverted L element. (N.B. The 17 metre modification is not currently shown in the photographs below.)

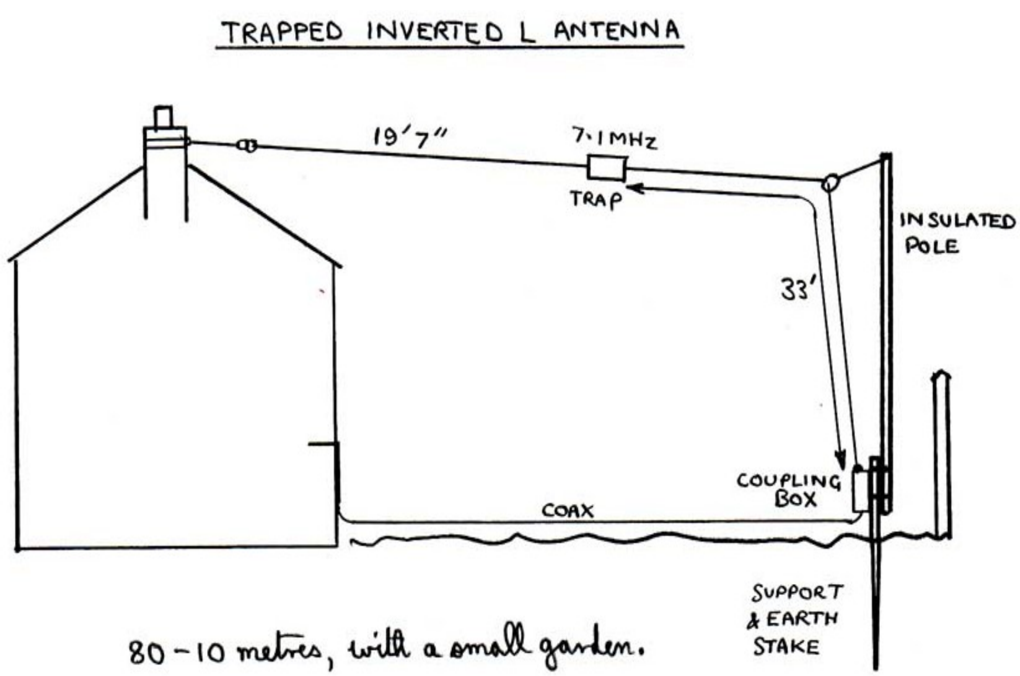
Work In Progress! - September 2011
Reconfiguring Inverted L with additional Top Band Loading Coil for 160 metres.
A strong 6 metre tall fibreglass pole replaces the original heavy wooden post.

Adding 160 metre loading coil to the 80m / 40m Inverted L Aerial.
The loading coil has a link wire to short it out of circuit when using the aerial for 80 metres and 40 metres.
The link wire is removed when Top Band is required.
The coil consists of approximately 37 turns wound on a piece of PVC pipe.

Adding 160 metre loading coil to the 80m / 40m Inverted L Aerial.
The loading coil has a link wire to short it out of circuit when using the aerial for 80 metres and 40 metres.
The link wire is removed when Top Band is required.
The coil consists of approximately 37 turns wound on a piece of PVC pipe.



Photograph showing the Inverted L antenna with additional vertical wire element and position of Delta Loop



The commercial version of the basic 80m - 10m Inverted L is available from Tony Nailer at [Spectrum Communications]

Important notes on effective Grounding by Jim K8OZ

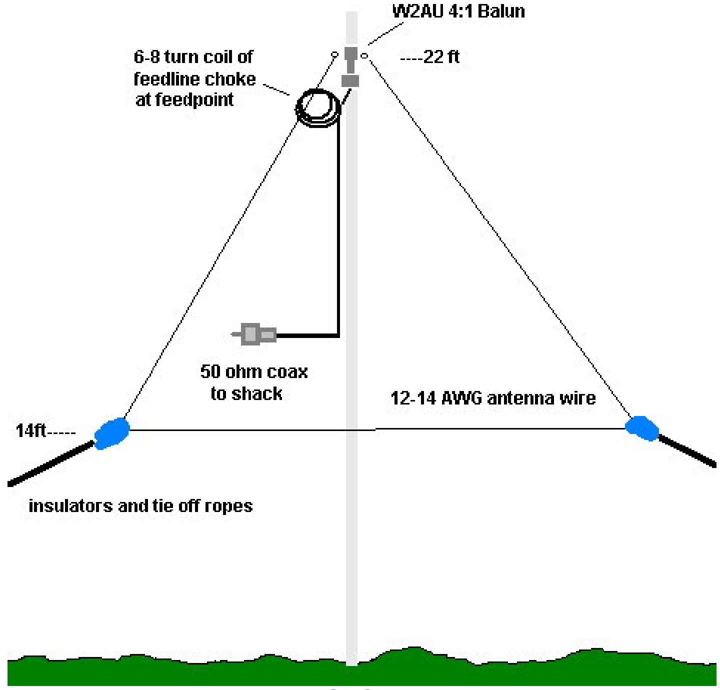
Mike - I was reading about your work on the 160 meter Inverted L, and it makes me want to go out and build some more antennas! Congratulations. Your story is fascinating, and very well documented.

The only thing I can offer as a suggestion is to get as much radial wire along the edge of your property as possible (assuming your XYL will not allow you to bury radial wire all over your yard). Even if you can only run multiple wires 1/8th of a meter apart from each other, and parallel to each other, your losses will be reduced. The ground lossses have quite an impact on your transmitted signal, so any wire you can "hide" along the edge of your property will help improve your signal strentgh - little, by little...! { It may also affect your resonant frequency slightly, but that's easy to deal with by adjusting with an antenna tuner or slightly changing the loading coil. }

Good luck OM, and keep up the refinements on your antenna system. You're doing great! 73,

Jim, K8OZ
Albuquerque, NM

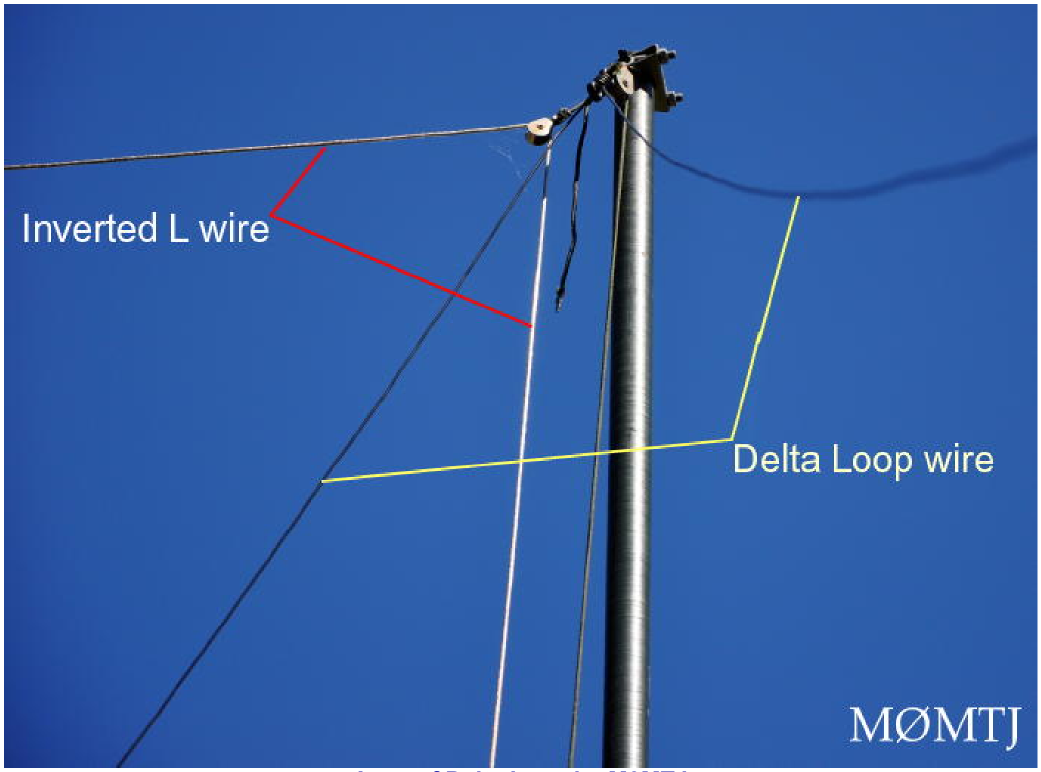
Delta Loop Antenna - Tuned for the 17 metre band but also usable as a multi-band operation



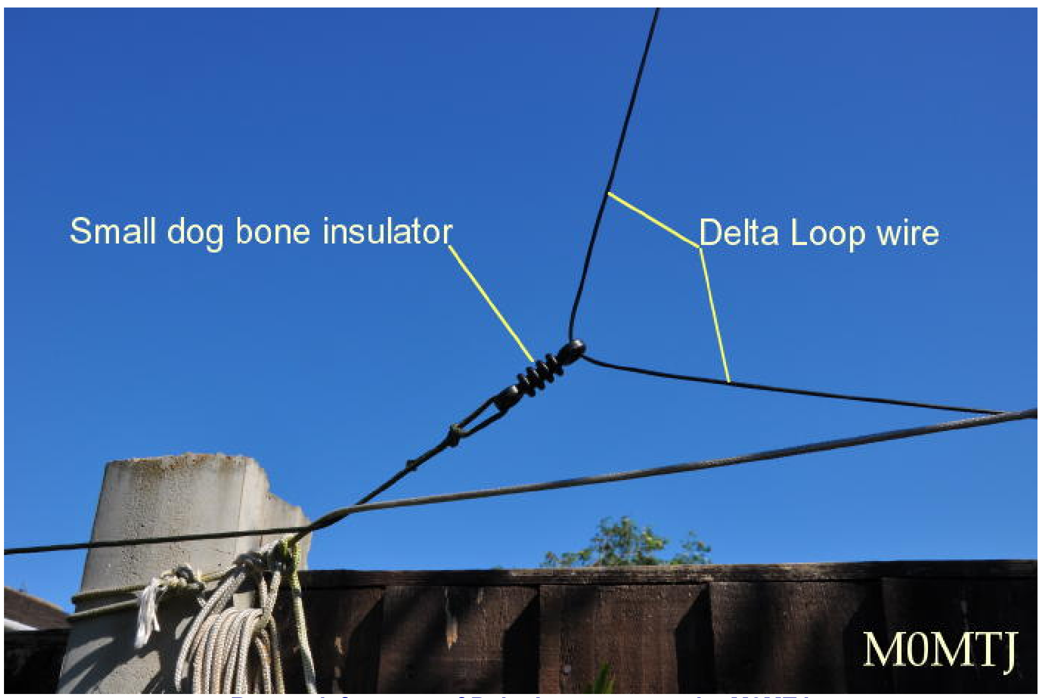
A typical Delta Loop antenna - diagram by W5SDC - gives multi-band operation with minimal cost.
My Delta Loop is fed near the bottom corner - it cannot be fed at the top, as in the diagram above, due to unwanted interaction with the antenna wire of the Inverted L antenna which is supported on the same pole.

My Delta Loop is fed near the bottom at one corner - it cannot be fed at the top, as in the diagram above, due to unwanted interaction with the antenna wire of the Inverted L antenna which is supported on the same pole.

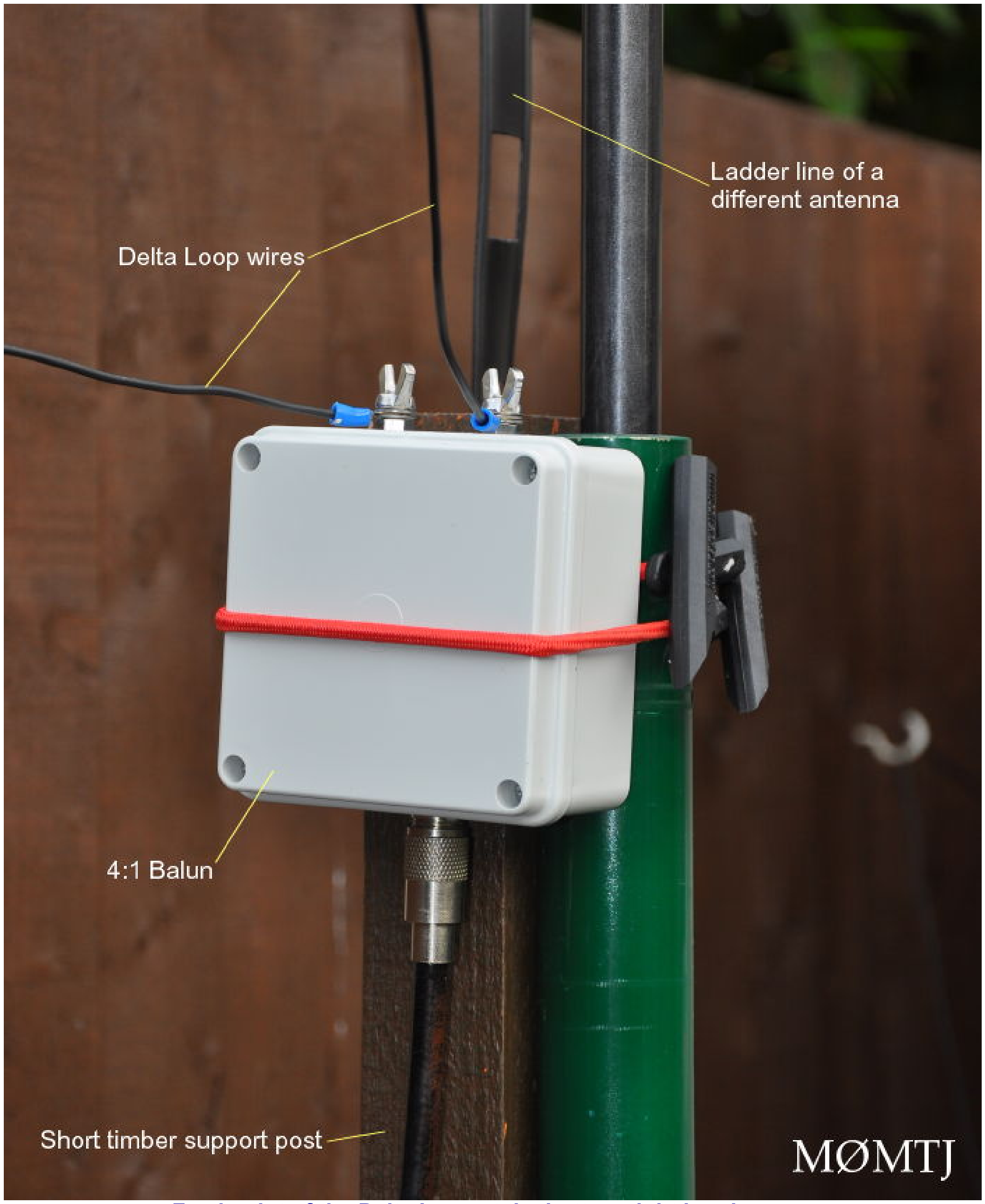
It consists of a 16 metre long loop of wire in triangular Delta shape, hung from the top of the pole supporting the inverted L antenna and fed via RG213 coaxial cable via a home-brew 4:1 balun. A loop is really a single band antenna cut for one wavelength on the band of interest, however it can also work on higher bands with an ATU - as a good, cheap and easy to install multi-band H.F. aerial. Performance is a little better than the inverted L on the higher bands, but on 10 metres the tuned 10 / 6 metre wire 'fan' dipole in the loft can still be better.



Apex of Delta Loop by M0MTJ



Bottom left corner of Delta Loop antenna by M0MTJ



Feed point of the Delta Loop at the bottom right hand corner

The Feed Point of the Delta Loop Antenna is at the bottom right hand corner
The Antenna is fed via a 'home brew' 4:1 balun by M0MTJ

Below are the VSWR measurements for the 16 metre long loop which has been measured an cut for resonance in the 17 metre band. For comparison are the measurements for the 12 metre long loop (which has not been optimised) and an 18 metre long loop which is of arbitrary length:

16 metre long loop of wire for the 17 Metre Band (optimised for 17m band)		
BAND	VSWR	VSWR
20m	14.0 MHz = 6.5	14.35 MHz = 4.9
17m	18.07 MHz = 1.2	18.16 MHz = 1.2
15m	21.0 MHz = 3.1	21.45 MHz = 3.7
12m	24.8 MHz = 5.9	25.9 MHz = 6.1
10m	28.0 MHz = 4.1	29.5 MHz = 4.4

12 metre long loop of wire for the 12 Metre Band (NOT optimised)		
BAND	VSWR	VSWR
20m	14.0 MHz = 22.1	14.35 MHz = 21.1
17m	18.07 MHz = 8.4	18.16 MHz = 8.1
15m	21.0 MHz = 5.0	21.45 MHz = 4.6
12m	24.8 MHz = 1.9	25.9 MHz = 2.0
10m	28.0 MHz = 5.0	29.5 MHz = 6.1

18 metre long loop of wire (An arbitary length between 20m & 17m)		
BAND	VSWR	VSWR
20m	14.0 MHz = 2.1	14.35 MHz = 1.4

17m	18.07 MHz = 2.6	18.16 MHz = 2.5
15m	21.0 MHz = 6.8	21.45 MHz = 8.4
12m	24.8 MHz = 6.3	25.9 MHz = 6.5
10m	28.0 MHz = 2.9	29.5 MHz = 2.5

Many users claim that loop aerials are quieter than typical vertical antennas. There are many plans available in the internet and given a suitable support or pole and a 4:1 balun it can take only a few minutes to install a loop antenna.

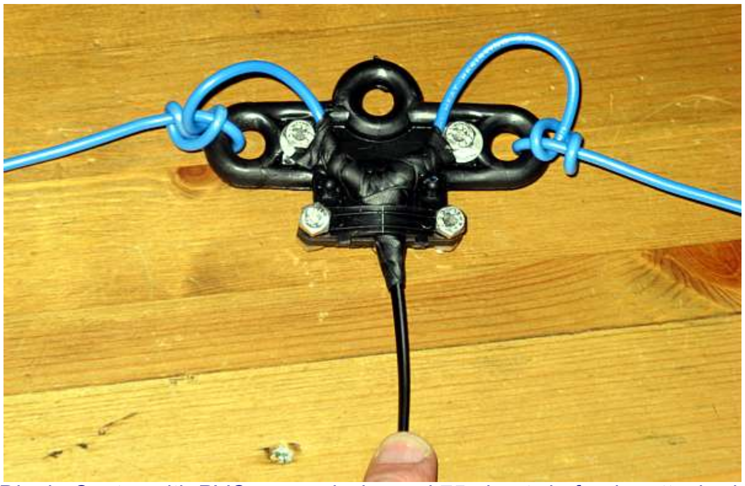
Arthur M0PLK (SQ2PLK) at Ham Radio Shop supplies an interesting lightweight self supporting Delta Loop antenna: http://ham-radio.urbasket.eu - see the review on the Polonia DX Award here: http://pdxa.one.pl/articles.php?article_id=17

LOOP ANTENNA LINKS: See lots more links to Loop Antennas on my links page here

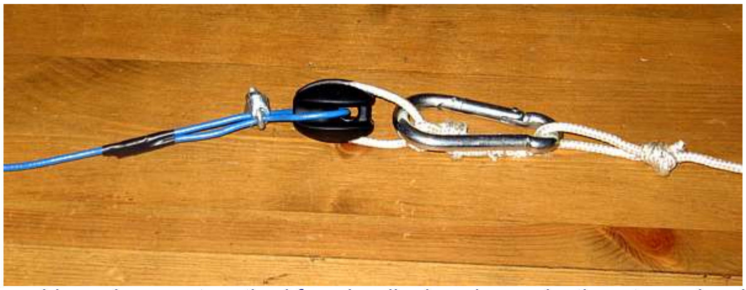
Dipole or Doublet Antenna for 20m and 10m

This is an antenna trapped dipole for 20m and 10m. Currently it is fed by 75 ohm twin feeder to a 1:1 balun in the loft, then on to the ATU (AMU) via a short RG213 coaxial cable. Although it was initially installed horizontally, it is now installed with one leg supported vertically on a 7 metre fibreglass 'Sota' pole with the other leg supported horizontally about 2 metres above the ground. This is a rather unorthodox arrangement for a balanced dipole, but it seems to work ok and was inspired by another radio amateur's idea - although I don't recommend balanced feeder for this arrangement!

It looks much neater than the horizontally strung dipole and offers a more omnidirectional radiation pattern too.



Dipole Centre with PVC covered wire and 75 ohm twin feeder attached.



Removable end support method for wire dipole using a plastic antenna insulator, snap-hook and Dacron rope.

Photo showing how the wooden support posts are held in the ground by the steel Met Post.
This Met Post and wooden pole now supports the 7 metre high fibreglass Sota Pole (fishing pole).

The 'deformed dipole'.

A Dipole for 20m and 10m.

One leg is vertical, giving a more omnidirectional pattern and supported by the 7 metre long fibreglass fishing pole, while the other leg runs off horizontally at about 2 metres above the ground.

This antenna is fed by 75 ohm twin feeder.

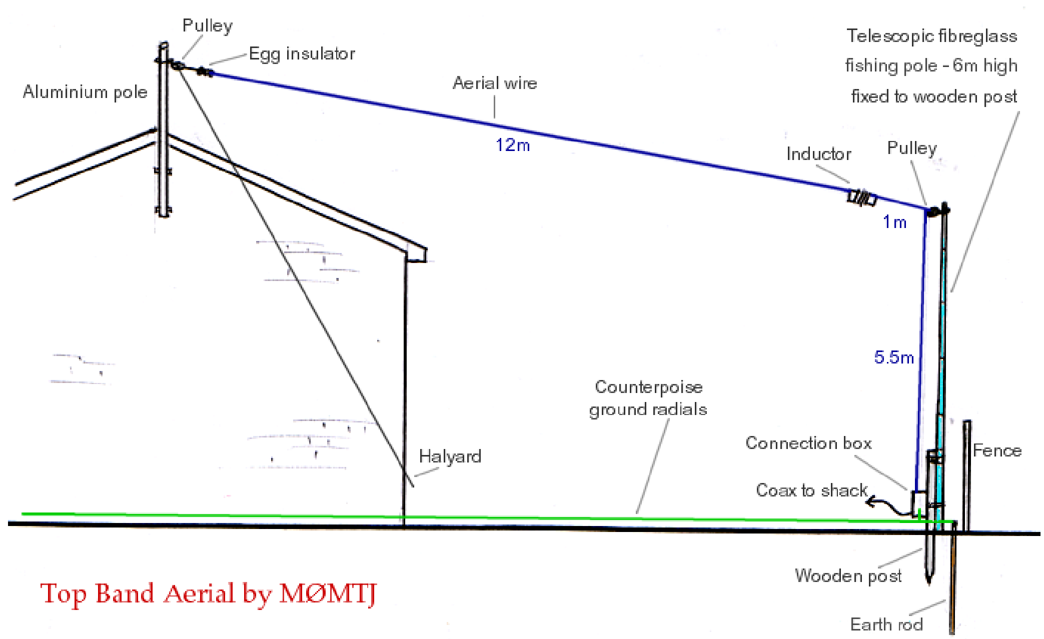
The Deformed Dipole

Compact Antenna for Top Band

A Shortened Inverted L for 160 Metres

Despite the dreadful noise on top band caused by modern electronic gadgets and the difficulty in accommodating a necessarily large aerial in a small garden, I was keen to try to get on to top band. I experimented with some different ideas during 2009, some of which are shown on this page.

Eventually I settled on the design shown below. It is an Inverted L type aerial, shortened by the use of a loading coil. It uses a fibreglass telescopic fishing pole to allow it to be easily lowered out of sight when not in use. Read more on Antennas page 2 here>



Shortened Base Loaded Top Band Antenna For Small Gardens
uses a fibreglass telescopic fishing pole to allow it to be easily lowered out of sight when not in use.

Read more about Top Band Antennas on Antennas page 2 >

Other Antennas:

End Fed Zepp Antennas for 20m / 17m and 15m :

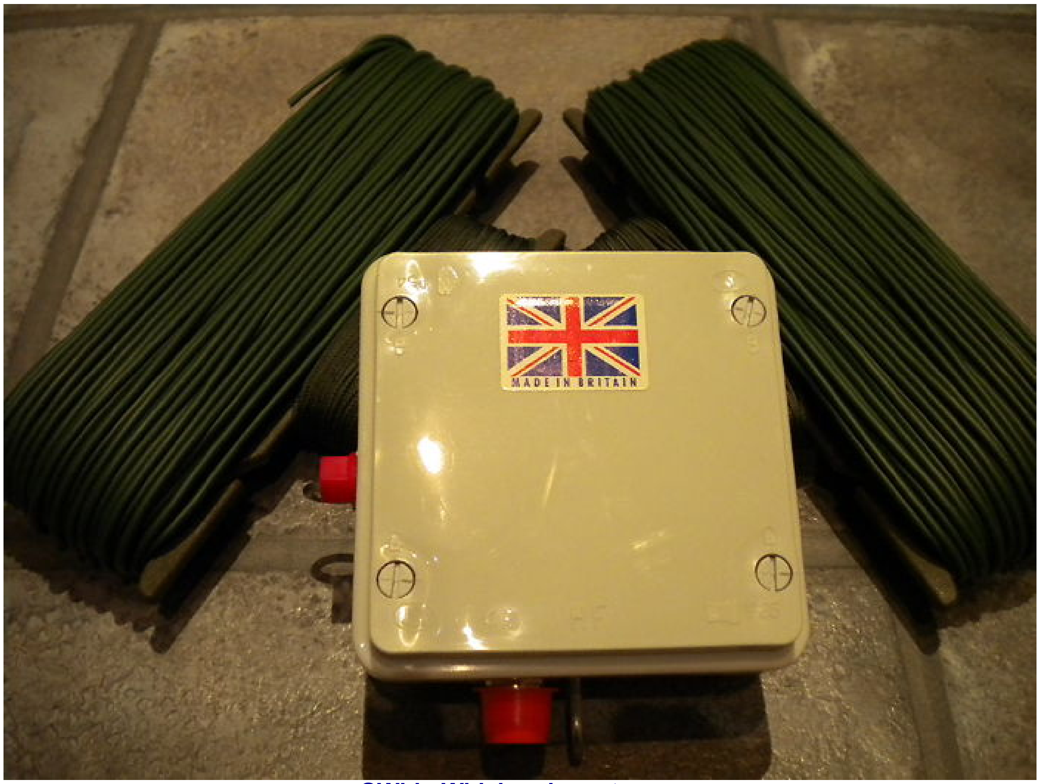
High quality commercially built Zepp antenna from G Whip Antenna Products.
http://www.gwhip.co.uk/

Above is a high efficiency, high quality commercially built Zepp style antenna using a half wave radiator. However there is a difference - unlike the traditional Zepp antennas, G4ICD's design dispenses with the long trailing 1/4 wave twin feeder matching section and counterpoise and, instead, uses a G-Whip's helical tuned unit.

The end fed Zepp is extremely versatile - it can simply be hung from the fascia board or guttering just outside one's window: The 1/2 wave wire radiator made of high strength Kevlar is easily sloped down the garden and is a camouflage green in colour so as to be almost invisible. The G-Whip Zepp is supplied with a fascia board insulator, a throwing line with plus cable strain relief and fittings, the IP65 waterproof resin potted box fitted with UHF connectors (SO239) for coax feeder. The Zepp can be mounted vertically (e.g. using a telescopic fibreglass pole), horizontally or sloping and can be ready in a matter of minutes.

I then decided to try an excellent new design developed by Geoff G4ICD - an End Fed Zepp antenna with a difference. The G-Whip End Fed Zepps are high efficiency, resonant mono band antennas utilising a half wave radiator, however this new G-Whip design by G4ICD dispenses with the long trailing 1/4 wave twin feeder matching section and counterpoise and, instead, uses a helical tuned unit. Using versions for 20m, 17m and 15m will enable me to get on the air with the minimum of fuss since the G-Whip end fed Zepp can simply be hung from the facia board or guttering just outside one's window. The high-strength Kevlar, camouflage green 1/2 wave wire radiator is easily sloped down the garden to be almost invisible.

G-Whip Widebander :



GWhip Widebander antenna.

Using the popular idea of feeding a large but non resonant antenna with an impedance converting 9:1 unun.

The G Whip wideband antenna consists of a 9:1 unun of GWhip's customary high quality for best efficiency, two 20metre lengths of kevlar wire for the radiator and counterpoise which provide operation from 3.6MHz to 50MHz. Feed with good quality low loss coax and use an ATU to match. The 20 metre radiator wire can be used as a sloper, or supported by convenient supports such as poles or trees in a straight line or 'dog legged'. I use a shorter radiator wire run up a telescopic fibreglass pole for operation on 20 metres an above.

Dual Band J-Pole :

There is a dual band vertical J-Pole antenna in the loft as a back up for the 2m and 70cm bands.

The excellent Dual Band N9TAX Slim Jim antenna that I use in the loft as a reserve antenna.
More information from Joe N9TAX at: www.n9tax.com
www.ebay.co.uk/itm/VHF-UHF-Slim-Jim-J-Pole-Dual-Band-2m-70cm-Antenna-jpole

Previous Antenna installations:

(2011 - 2013)

1) A trapped Inverted L for 80m and 40m with an SGC-230 auto antenna coupler at its feed-point at the bottom of the garden. RG213 coaxial cable is used to feed the output of the auto-coupler back to the shack. This can be used on all bands from 160 through to 10 metres. The support post is installed at the bottom of the garden with the end of the antenna wire being supported by Dacron rope that is attached to a pulley on a pole at the apex of the roof. A simple, single sloping wire element provides use on the 17 metre band. Although too short to be really effective on 160 metres, Top Band can be tuned by the SGC coupler. A pretty good all-round antenna. more

2) A half wave Wire J-Pole fixed to a telescopic fibreglass fishing pole for 10m. Cheap and effective. more about J-Poles

3) A 'home-brew' omnidirectional, vertical dual band, end fed antenna for 2 metres and 70cm. This is of the Controlled Feeder Radiation design (CFR) by VK2ZOI; effectively an end fed half wave dipole on 2m with an aluminium sleeve to achieve 70cms with a few extra dB's of gain. It is mounted on an aluminium mast 10 metres a.g.l. more

4) A DK7ZB design dual band Yagi antenna, with 5 elements for 2 metres and 8 elements for 70cms, mounted horizontally for SSB. A lightweight antenna rotator is employed and uses a push-up telescopic mast. Height above ground level is again approximately 7 metres. The DK7ZB is an excellent twin band Yagi antenna. more

5) Dual Band Fan Dipole, made from thick loudspeaker wire, mounted horizontally in the loft space for 10 meters an 6 metres. Cheap & effective.

6) (Installed late September 2013) Wire J-Pole antenna for 4 Metres (70 MHz) supported on a 3 metre long telescopic fibreglass pole to be attached to the top of the aluminium push up mast that supports the DK7ZB dual band yagi and rotator,

Other Options that can be deployed on an 'as required basis':

7) Compact Loaded Top Band Antenna, based on a design idea by Stuart Craigen G4GTX more

8 & 9) G Whip End Fed Zepps (EFZ's) for either 20m, 15m or 17m or the G-Whip "WideBander" which is an 'UnTenna' style antenna that can be used for 20m through to 10m using good quality G Whip 9:1 UnUn; useful additions for antenna flexibility. more

10) N9TAX Dual Band Slim Jim (J-Pole) antenna mounted in the loft as a back-up antenna for 2m and 70cms. Very good. more

11) Delta Loop Antenna - 16 metre loop of wire in triangular Delta shape, hung from the top of the pole supporting the inverted L antenna and fed via RG213 coaxial cable via a 4:1 balun. The loop is really a single band antenna cut for one wavelength on the band of interest, however it also can be pressed into service for some higher bands - a good, cheap and easy to install aerial; Often works better than the inverted L on the higher bands, but on 10 metres the tuned 10 metre dipole in the loft is sometimes better. more

(2011)

In mid 2011 I experimented with an excellent N9TAX designed dual band Slim-Jim (J-Pole) antenna for 2m and 70cms. This is made from lightweight 450 Ohm ladder line which can be fixed to the top of a 10m tall fibreglass, telescopic, fishing pole. The N9TAX works extremely well indeed. More information from Joe N9TAX at: www.n9tax.com and buy at: www.ebay.co.uk/itm/VHF-UHF-Slim-Jim-J-Pole-Dual-Band-2m-70cm-Antenna-jpole

N.B. I tried to home-brew the DJB-1 dual band J-Pole antenna using plans published by the ARRL in QST magazine. I wanted a neat antenna that could be enclosed in a protective tube to minimise weathering effects. However trying to tune this antenna at UHF frequencies proved to be frustratingly difficult to do and after two full days work I could not get the thing resonate accurately at the correct frequency. Sadly, for this reason, I cannot recommend the Dual Band J-Pole as a home-brew project.

The N9TAX antenna on the other hand works very well. However it cannot be enclosed in a tube due to the velocity factor effect de-tuning the antenna's resonant frequencies.

(Late 2011)

Due to difficulties with the stability of a lightweight fishing pole as a support I moved back to using the lightweight aluminium telescopic mast, with stays, to support a Watson W-50 vertical dual band collinear for 2 metres and 70 cms FM.

The excellent N9TAX dual band Slim Jim is now installed in the loft.

(Antennas used up until 2010)

1) A trapped Inverted L for 80m and 40m fed by RG213 coaxial cable to the LDG Z-11 Pro antenna matching unit in the shack. This can be used on all bands from 80 through to 10 metres. The support post is installed at the bottom of the garden with the end of the antenna wire being supported by Dacron rope that is attached to a pulley on a pole at the apex of the roof. This excellent antenna is still use. more

2) A trapped dipole for 20m and 10m. This was fed by 75 ohm twin feeder to a 1:1 balun then on to the AMU via RG213 coaxial cable. It was initially installed horizontally, but more latterly installed with one leg supported vertically on a 7 metre fibreglass 'Sota' pole with the other leg supported horizontally about 2 metres above the ground. A rather unorthodox arrangement for a balanced dipole, but it seemed to work ok, it looked much neater than a horizontally slung dipole and also offered a more omnidirectional radiation pattern. more

4) A compact Inverted L for the 160 metre band - Top Band - shortened with a loading coil. more

5) As N9TAX Dual Band Slim Jim (J-Pole) antenna for 2m and 70cms. This was fixed near the top of a 10m telescopic fibreglass fishing pole that I pushed up whenever it was required. more

(2008)

W-2000 - Vertical Collinear mounted on a temporary 10m telescopic pole:

I no longer have the Watson W-2000 but this is how it was used previously:

The Watson W-2000 covered VHF (2 metres / 144 MHz) and UHF (70 cms / 430 MHz) and also, rather usefully, 6 metres (50 MHz) too. The W-2000 is 2.5 metres long and enclosed in white fibreglass with three radial elements at the base.

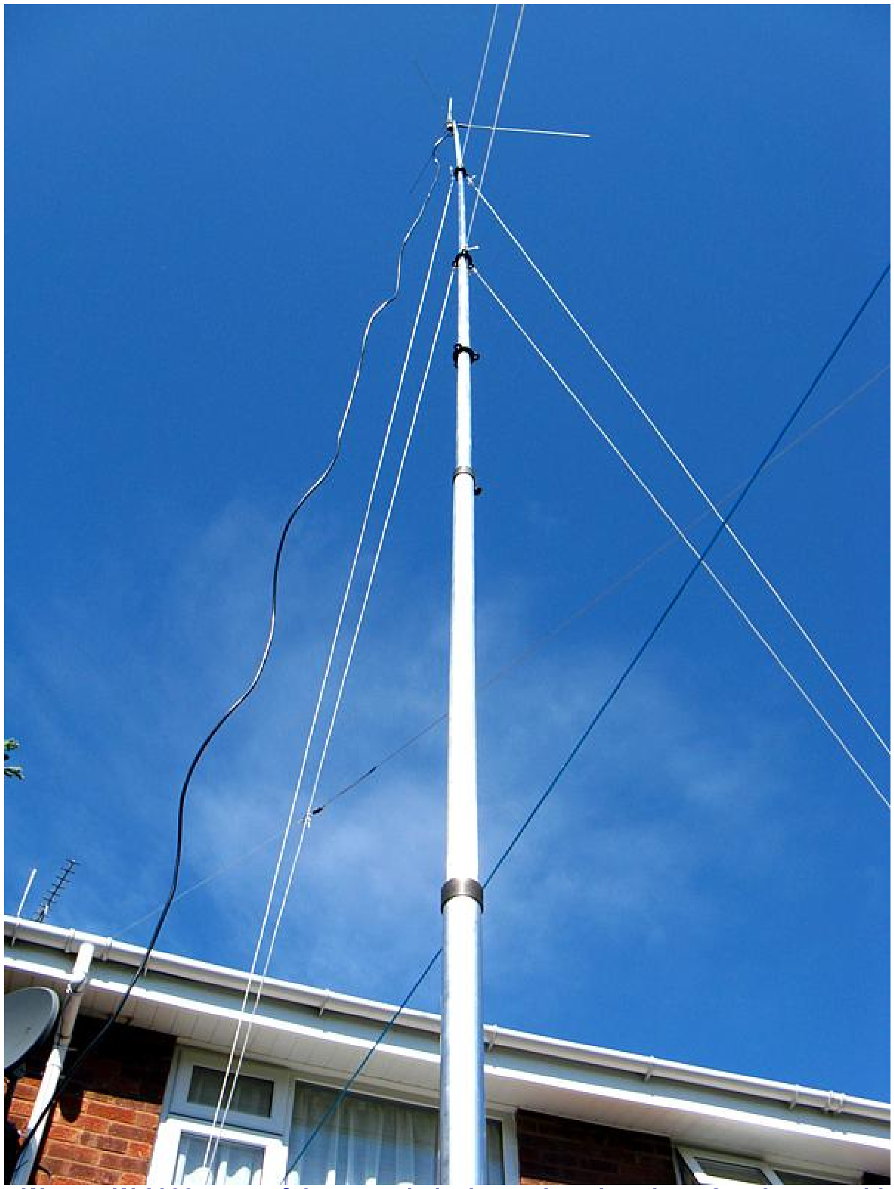
Unfortunately I had nowhere practical to install a separate mast for the VHF / UHF antenna, so this was mounted on top of a 30 foot (10 metre) high telescopic aluminium mast in the back garden. The base of the mast was placed in a handy metal sleeved hole that was already present in a small wall in the garden. Very fortunate indeed!

The antenna is connected to the radio via the very low loss Westflex 103 coaxial cable. The cable was left in place permanently, running from the shack in the front bedroom, up into the loft and out of a small hole in the back of the house, down a drain pipe into the back garden. From there the aerial can be connected as an when required:

When VHF or UHF operation is required I have to connect the coaxial cable to the Watson W-2000, fix it to the top of the telescopic mast, which is very quick using two V bolts and 4 wing nuts, put the mast in the hole and raise it to a good height. I tend to extend it so that the bottom of the antenna is at about 24 feet in the air, the height of the apex of the house, so it is in fairly clear space.

A VHF and UHF aerial needs to be as high as possible since at these frequencies communication is essentially local and 'line of sight' - unless heightened propagation conditions, such as Sporadic E or a Temperature Inversion is prevailing at the time.

Even at 24 feet the mast is rather wobbly, so it was tied down using three nylon guy ropes.



The Watson W-2000 on to of the extended telescopic pole - about 8 or 9 metres high.

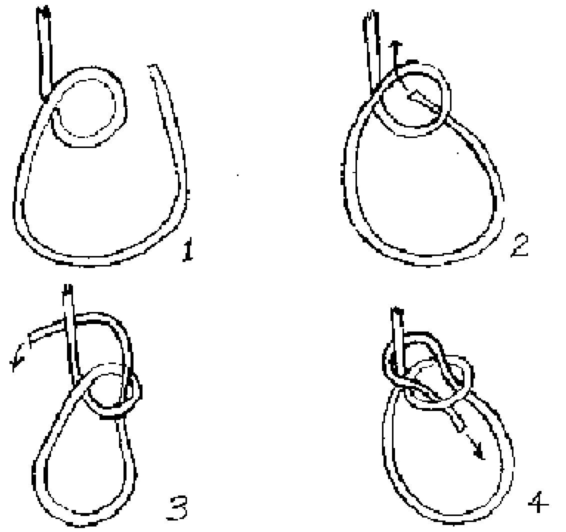
Photograph of a Watson W-2000 on Telescopic Mast at the lowest position.

MORE ANTENNAS

Our good friend in Australia Felix Scerri, VK4FUQ, uses Inverted V antennas but also highly recommends the Quad Loop style antenna for HF work. These are well worth investigating, and you can read more here: Antennas 3 with more antenna ideas on Antennas 2 and Antennas 4 and the Links Page here and here

KNOTS FOR SECURING WIRE ANTENNAS

I have found the Bowline to be one of the most useful, it is strong and easy to tie. A Bowline will not slip in any circumstances and, usefully, the more load that is put on it, the tighter it gets. Read more about good knots for amateur radio aerials here...



The Bowline Knot - Read more about knots here ...

Antenna Trimming Chart and useful Antenna Rigging Accessory ideas

On Antennas 4 I have included a helpful Antenna Trimming Chart and some useful ideas for Antenna Rigging Accessories

More project ideas here>

73

Mike, M0MTJ 2011 / 2012

Antennas 2 | **Antennas 3** | **Antennas 4** | **Antennas 5** | **Antennas 6**

Links to further reading:

Introducing The All Band Doublet: http://www.cebik.com/content/edu/edu6.html ***N.B. Create a free account at*** http://www.cebik.com

The All Band Doublet - http://www.cebik.com/wire/abd.html

The ALL Band HF Doublet on Ham Universe - http://www.hamuniverse.com/hfdoublet.html

Multi Band Dipoles Compared - by ARRL on QST and DX Zone:
http://www.arrl.org/tis/info/pdf/9611073.pdf http://www.dxzone.com/cgi-bin/dir/jump2.cgi?ID=7499

PDF Document - The W3DZZ Antenna -
http://www.users.icscotland.net/~len.paget/GM0ONX%20trap%20dipole.pdf (**!!! But don't use coaxial cable with a 'choke balun' at the centre of the dipole! Use twin feeder with the Choke Balun at the other end. Less power loss.!!!***)

See Practical Dipole Antennas Compared: http://www.qsl.net/ta1dx/amator/practical_dipole_antenna.htm

Practical Antenna For 160 Metres - http://www.iw5edi.com/ham-radio/?a-practical-antenna-for-160-metres,32
http://www.ik1mnj.net/id202.htm

More:

The website of GM0ONX http://www.gm0onx.co.uk/

The Inverted L - PDF document: http://www.users.icscotland.net/~len.paget/5%20band%20Inverted%20L.pdf

Adding Top Band To The Inverted L - PDF Document:
http://www.users.icscotland.net/~len.paget/Inverted%20L%20adding%20top%20band.pdf

The All Band Inverted L - http://www.antennex.com/preview/archive3/ltv.htm

Q.T.H. Move in 2010 !%*?"*!?!

We decided that we'd like to move house in 2009, we found a new property in early 2010. My amateur radio aerials were duly taken down and the ham shack packed away. However after months of delays we still had not moved by August 2010, but we were still hoping to move. However after months of messing about and stringing us along our buyer pulled out the very day before we were to exchange contracts later in August 2010.

This cost us a lot of time and a great deal of wasted money. Thank you Mrs xxxxxx :-(

After a wasted year we decided to stay where we were and take the house of the market. Instead we spent the next eight months remodelling and redecorating. No time for playing radio of course and besides everything was still all packed away in boxes!

In mid 2011 I was getting frustrated that I had no radio. So I suppose it's time to think about re-establishing the station and to start planning the installation of some antennas. Of course Jules, my XYL, understandably questions my antennas and experiments!

Due to time constraints I will probably start again with a somewhat temporary antenna. I was thinking along the lines of an "Untenna" - so I installed a 7.2 ish long wire supported on a vertical fibreglass pole with a horizontal 'counterpoise' connected via a 9:1 balun to the coax back to the shack. Of course it is a fairly low efficiency multi-band (wideband) antenna, but easy to get going quickly. The GWhip Widebander antenna by Geoff Brown G4ICD is possibly the highest quality antenna of this type available, using a very high efficiency, top quality 9:1 UnUn with a 17 meter wire radiator and 10 metre long counterpoise - a very useful, versatile 'all situations' antenna.

As time progressed I re-established my full size trapped Inverted L antenna for 80metres and 40 metres and added a switchable loading coil at its base for use on 160 meters, as described above.

Then I gradually re-established the 2 metres and 70 cms antennas with the vertical W-50 and horizontal dual band DK7ZB Yagi - as detailed above.

Antennas 2 | Antennas 3 | Antennas 4 | Antennas 5 | Antennas 6

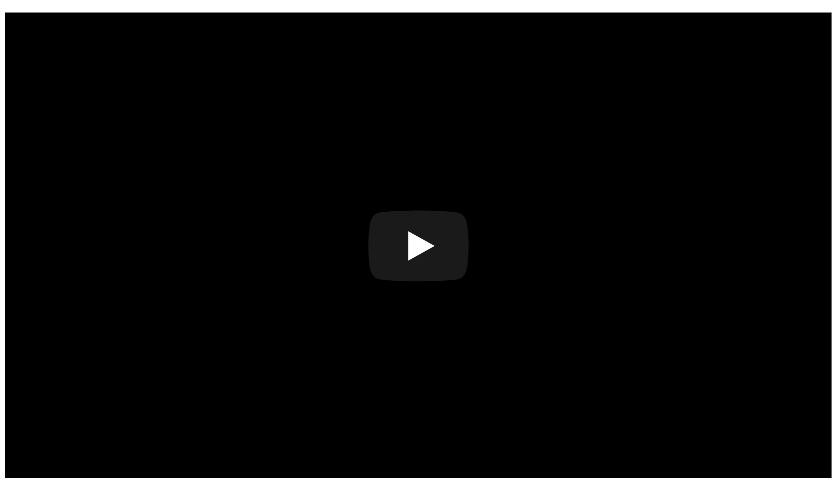
Index To Other Antenna Pages:
Antennas 1 : Aerials used at M0MTJ
Antennas 2 : Including ..... Ideas for compact aerials for Top Band /160 metres
Antennas 3 : Felix Scerri VK4FUQ discusses Loop Antennas, baluns, masts & other antenna related topics
Antennas 4 : Including ...... Many antenna ideas from various sources particularly for multi-band operation & also gives information about
antenna trimming, knots for wire antennas and useful antenna rigging accessory ideas.
Antennas 5 : Including ..... Half Wave End Fed aerials for 144 MHz VHF / 430 MHz UHF and 50 MHz 6 Metre band & J-Pole Aerials
Antennas 6 : Including .... Simple and effective H.F. Antenna ideas - Ground Plane and All Band Doublet

G-WHIP G Pro Whip antennas
http://www.gwhip.co.uk/

http://www.gwhip.co.uk/

Just For Fun:

A tower that we may like to have to attach our antennas to - but I don't think that Health And Safety was taken into account here:



M0MTJ | Operating Conditions | Antennas / Aerials | /P Portable Operating | Accessories | Projects & Kits

Useful Information | Contact MØMTJ | Contact M6ORS | Links to Amateur Radio Sites

RSGB | QSL | The Amateur Radio Mini Site Map

WSPR Weak Signal Propagation Reporter

News, Developments, Events, Photographs and other 'Bits 'n' Bobs'

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http://www.freeradio.co.uk/

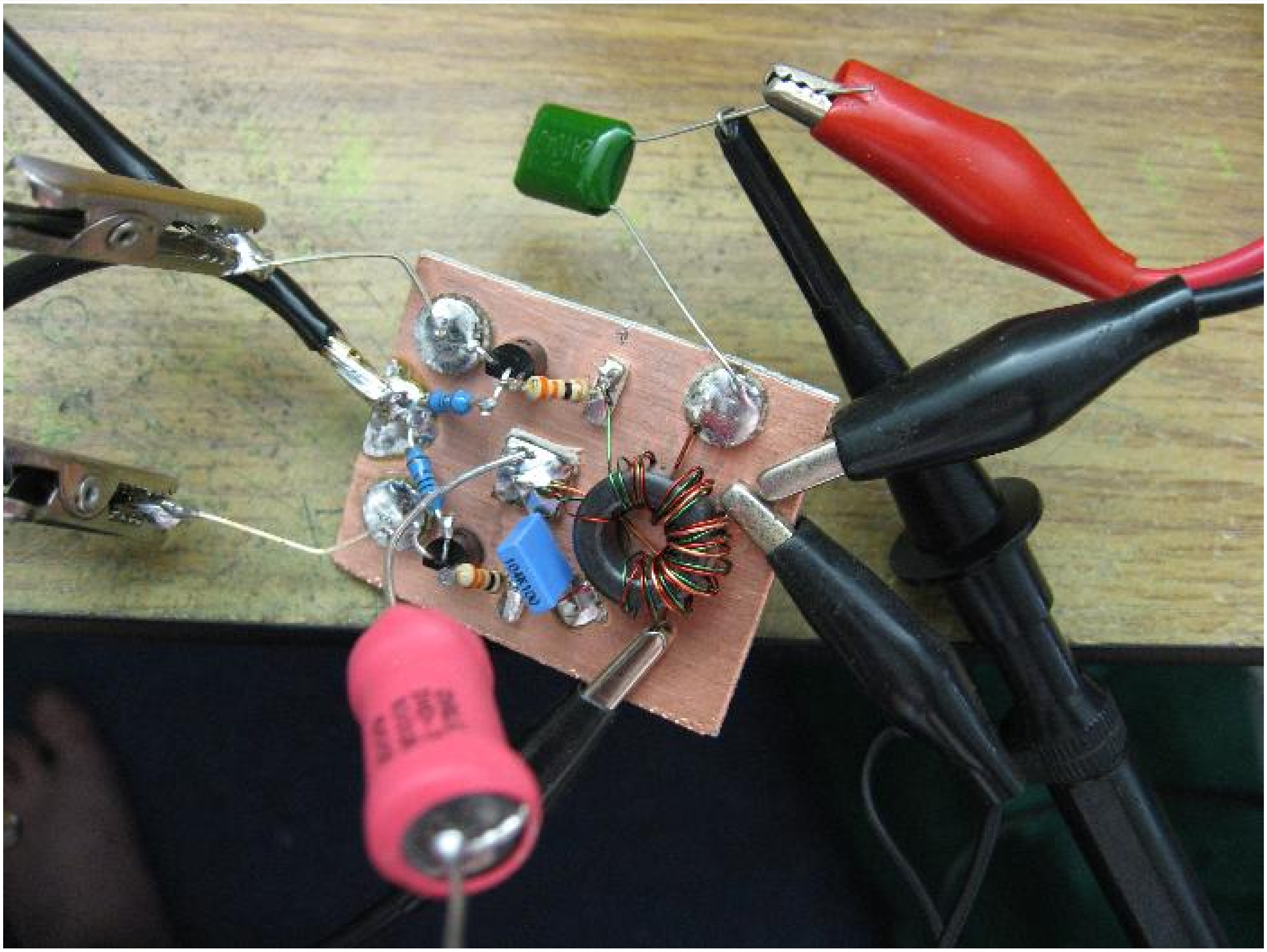
Phantom-Powered Active Loop Receive Antenna for 30 Metres

2010-03-27

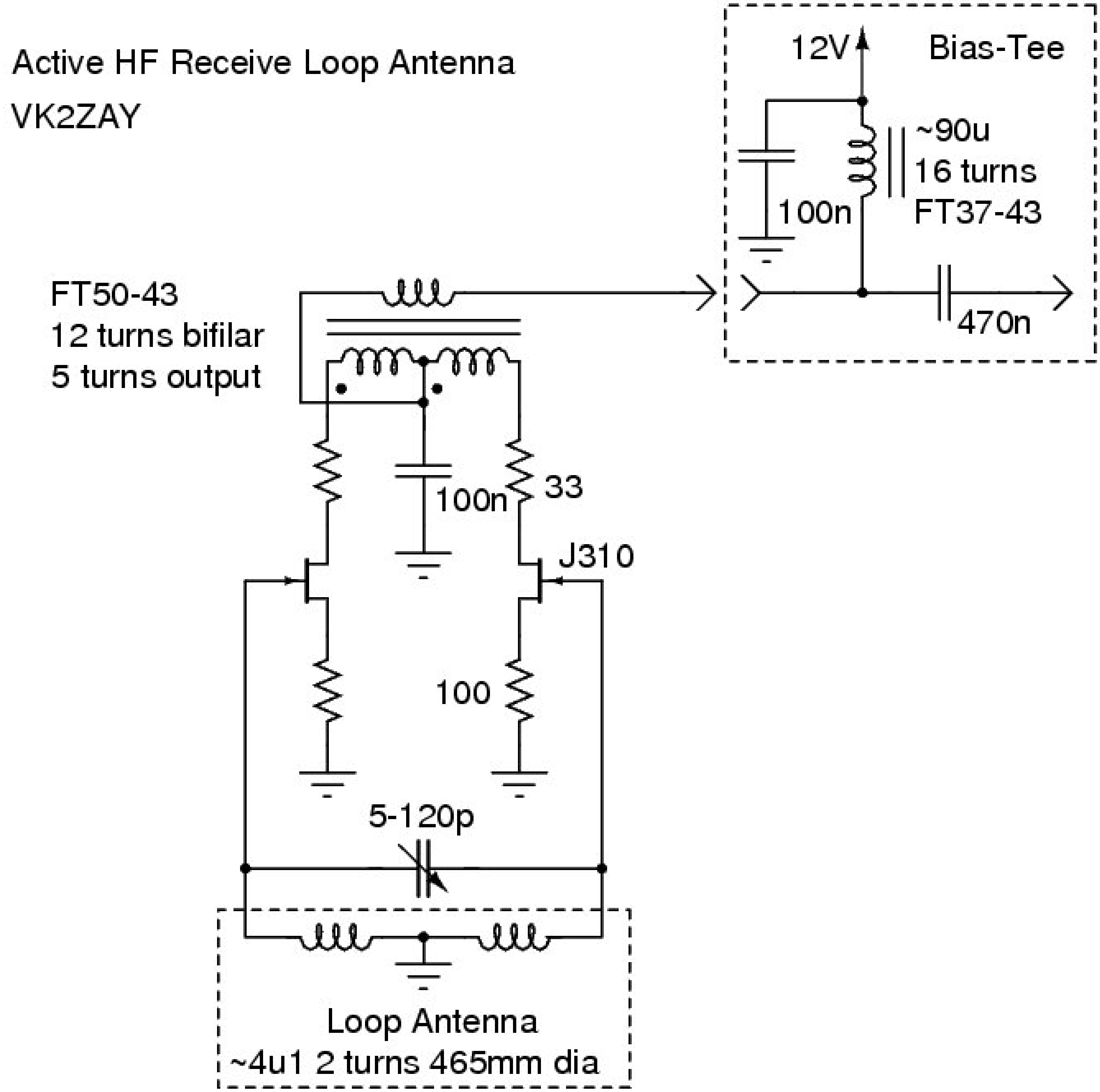
This loop antenna was built for 30 metre QRSS reception, but tunes beyond 30 metres and might be useful for general narrow-band (fix-tuned) HF work.

The Antenna

The loop is two turns of ~3 mm multi-strand hook-up wire, wound on a large (465 mm diameter) embroidery frame. The coil is centre-tapped, and referenced to "ground" at that point. A polyvaricon tunes the coil to resonance at the frequency of interest, and a push-pull JFET buffer amplifier transforms the very high impedance of the parallel resonant circuit down to something suitable for what is seen through the coax from the receiver (and also offers some power gain at the same time to offset feed-line loss). The buffer can deliver a relatively large amount of power, in excess of 0 dBm. This should offer good strong-signal handling, but I have not measured its IP3.



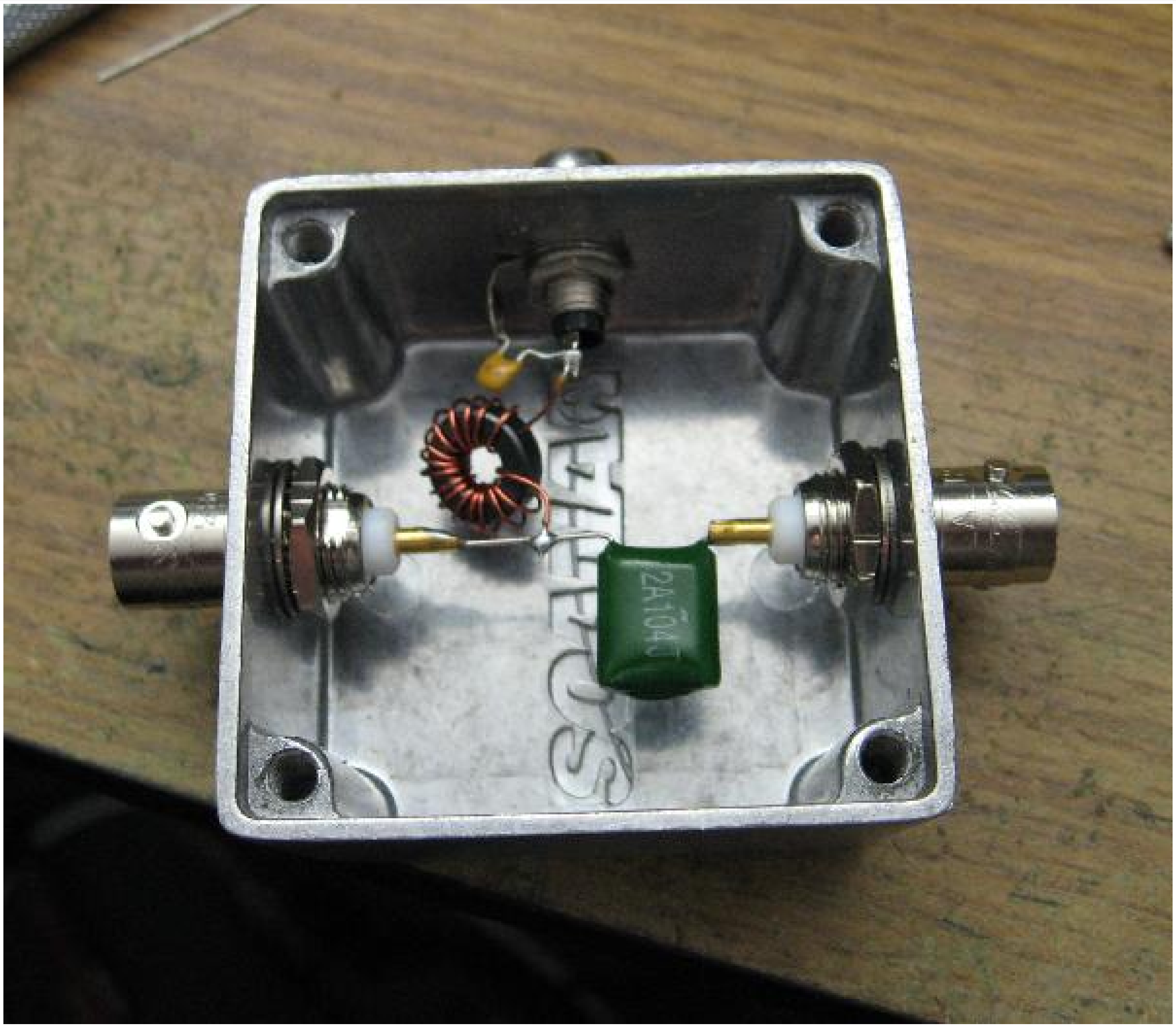
Each J310 stands about 2.5 mA. I hand-picked a pair of well matched J310s (by Vpp and Idss), this is likely unnecessary but it can't hurt to ensure each arm has similar biasing and gain to optimise the distortion cancelling effects. The 33 Ohm resistors in the drains help eliminate any tendency for spurious oscillation. The supply current feeds into the bifilar drain loads from the decoupled "cold"-end of the output winding, using it as a choke. This seems to work well in practice, with no visible distortion asymmetry (when over-driven) from the DC bias on the magnetics. (The standing currents in the bifilar winding cancel, but those in the output secondary do not, fortunately the supply current is only about 5 mA so this should be of no consequence. As long as the transistors saturate well before our ferrite core - an FT50-43 - we are in good shape.)



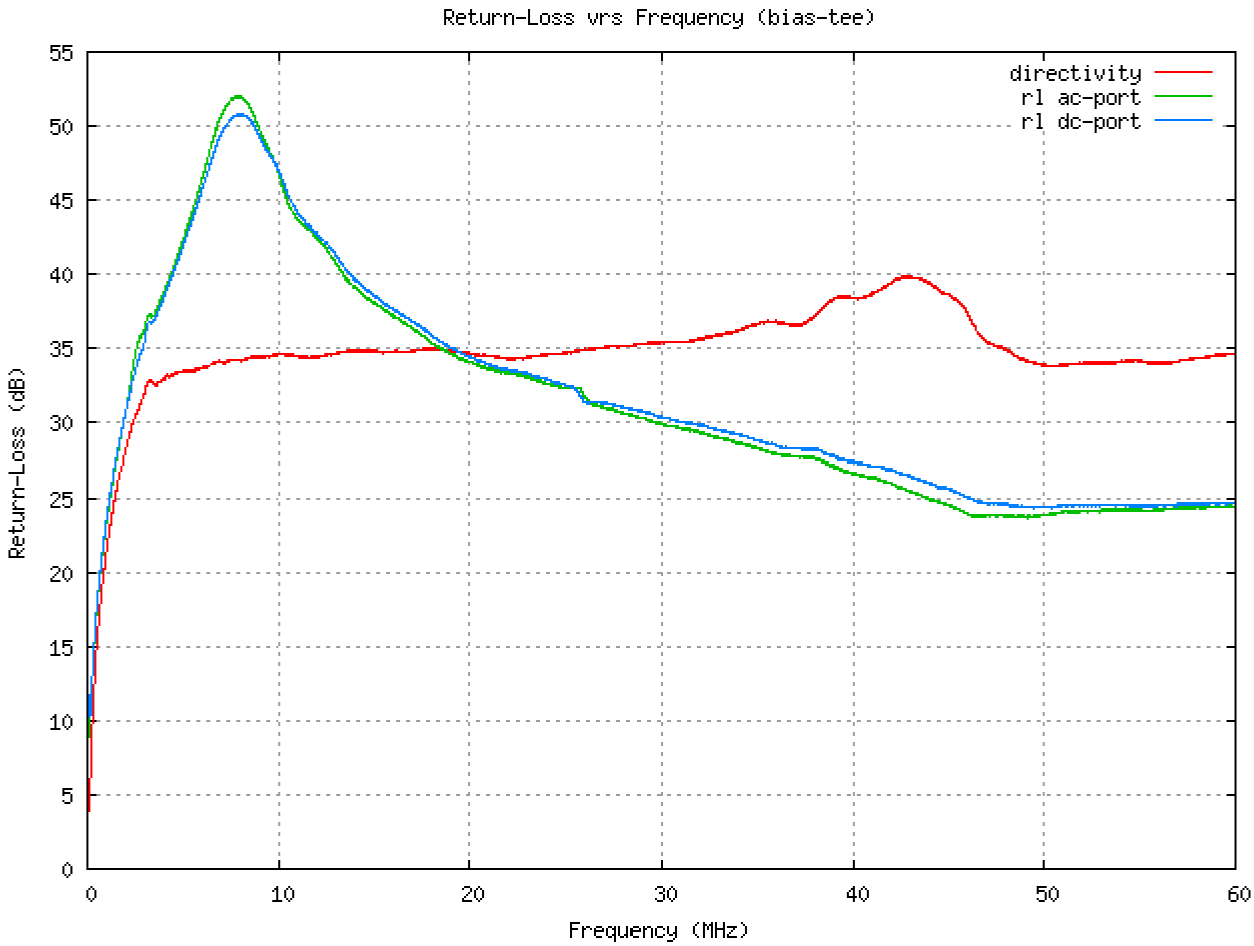
More gain is available by bypassing the 100 Ohm source resistors. Oscillation can occur with excessive gain. You can set the gain at a higher, but stable level by adding resistance in series with the bypass capacitors.

The Bias-Tee

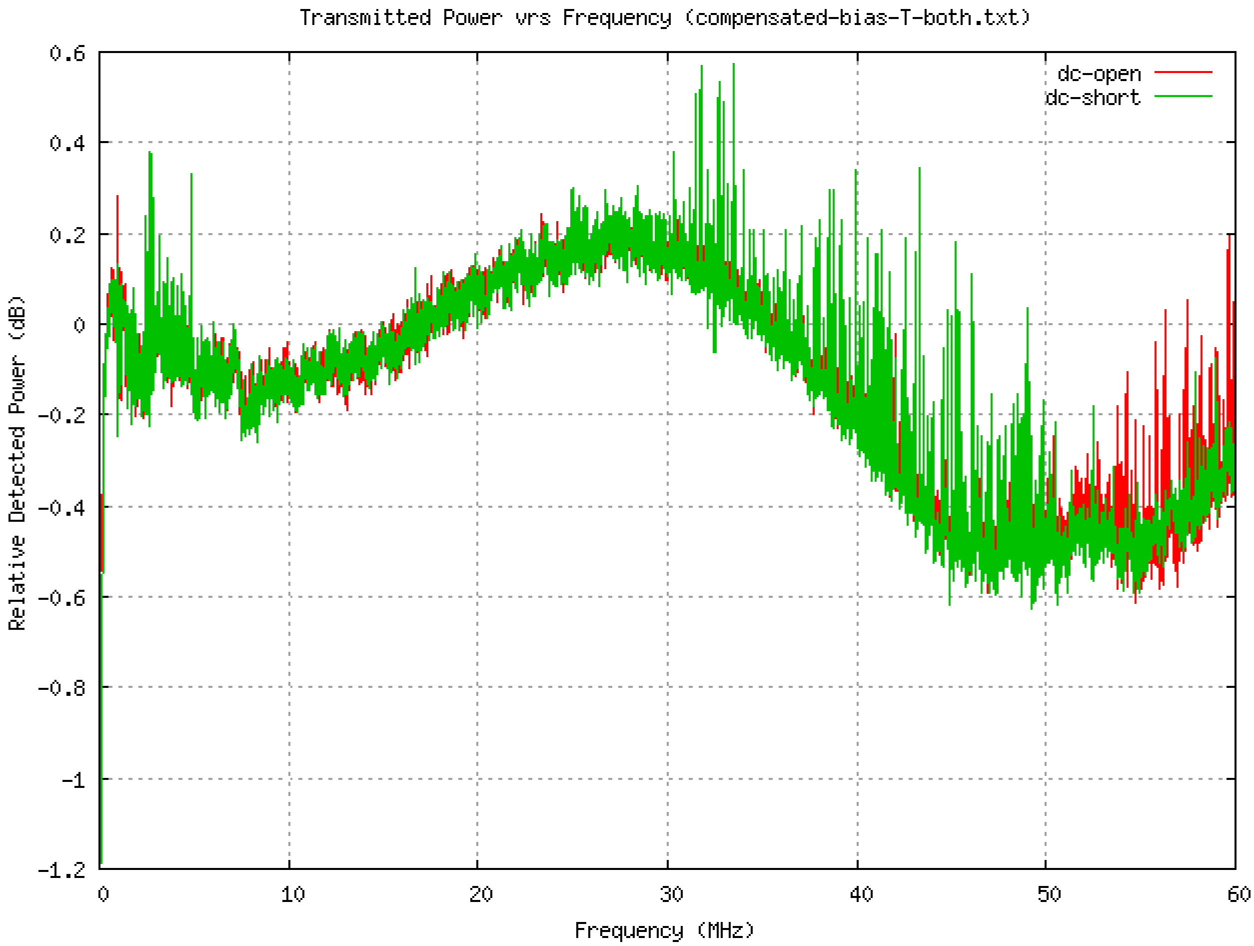
To feed the DC supply to the antenna at the shack-end of the coax a simple bias-tee was constructed. As the frequency of operation is only mid-HF a simplistic ferrite toroidal choke and two capacitor affair was constructed in a small die-cast box. I was confident this construction was sufficient at the frequency of operation, but curious about its performance elsewhere, as such it became one of the first test subjects for my experimental scalar network analyser.



Despite having very poor "design hygiene" for high frequency response, sweeps of the bias-tee with the analyser suggest it offers acceptable performance across HF. There are some oddities in these measurements however. Fortunately they appear to be measurement equipment problems rather than excessively nasty behaviour of the device under test:



Note how the measured "return-loss" exceeds the bridge directivity below 20 MHz. This is of course an illusion, caused by the small stray reactances of the bias-T conjugate matching the bridge for better than calibration reference balance. Ideally I should change the graphing software to compute error bars based on the reflection signal magnitude compared to the directivity established by Open-Short-Load calibration at the same frequency. As the directivity of the bridge exceeds 30 dB above a few MHz all the way to 60 MHz we can safely say the bias-Tee is an reasonable match over the same range displaying a return loss exceeding 20 dB the entire way.

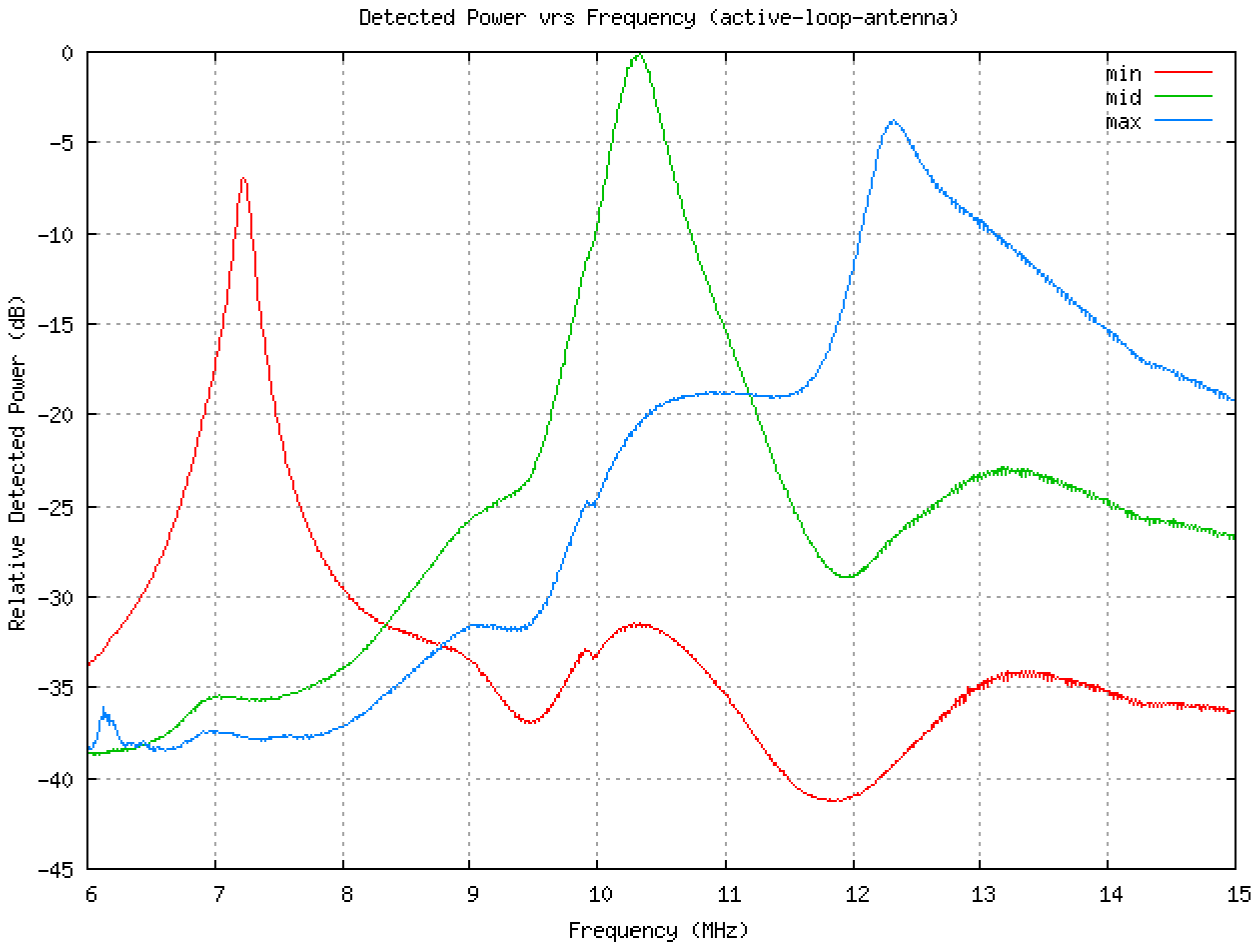


Transmission measurements similarly have some weirdness. Despite the test setup having 20 dB of attenuation in the signal path the bias-T performs the miracle of over-unity performance. Of course this is not real! Again it is just conjugate matching something in the system to make the reference calibration invalid. The variation is only a fraction of a dB so for all intents the bias-T is near-perfect across HF and into low VHF.

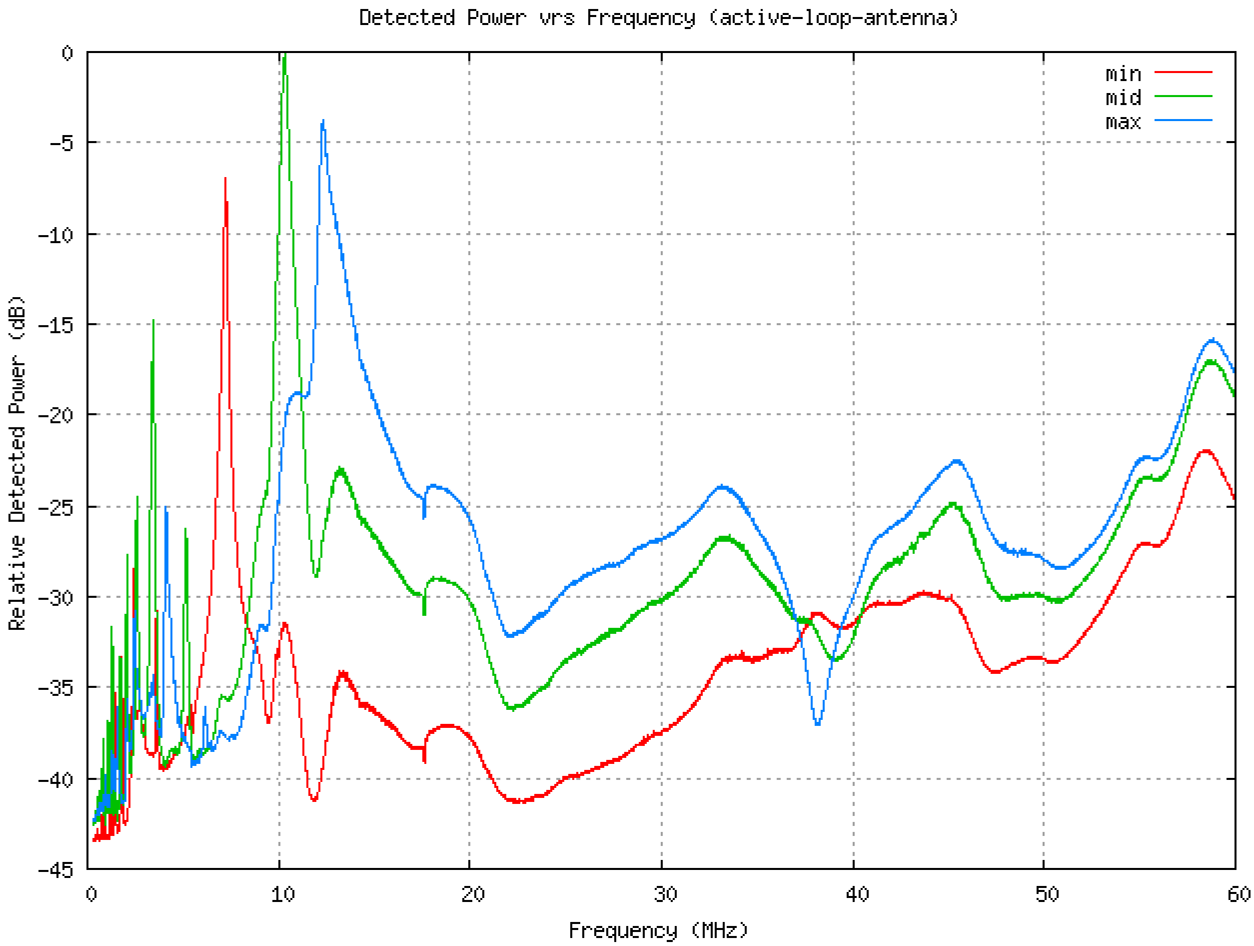
Lab Testing

It is rather difficult to lab test a loop antenna in a reasonable way. In particular it is extremely difficult to immerse it in a RF field of sufficiently controlled spatial uniformity and consistent amplitude with frequency to make absolute and repeatable measurements. For my initial testing a 100 mm diameter coupling loop was connected to the signal generator and loosely coupled to the antenna loop. Sufficient drive was applied to achieve a few dBm out of the loop buffer and into the power meter at peak of resonance. This allowed crude measurements of bandwidth and amplifier compression.

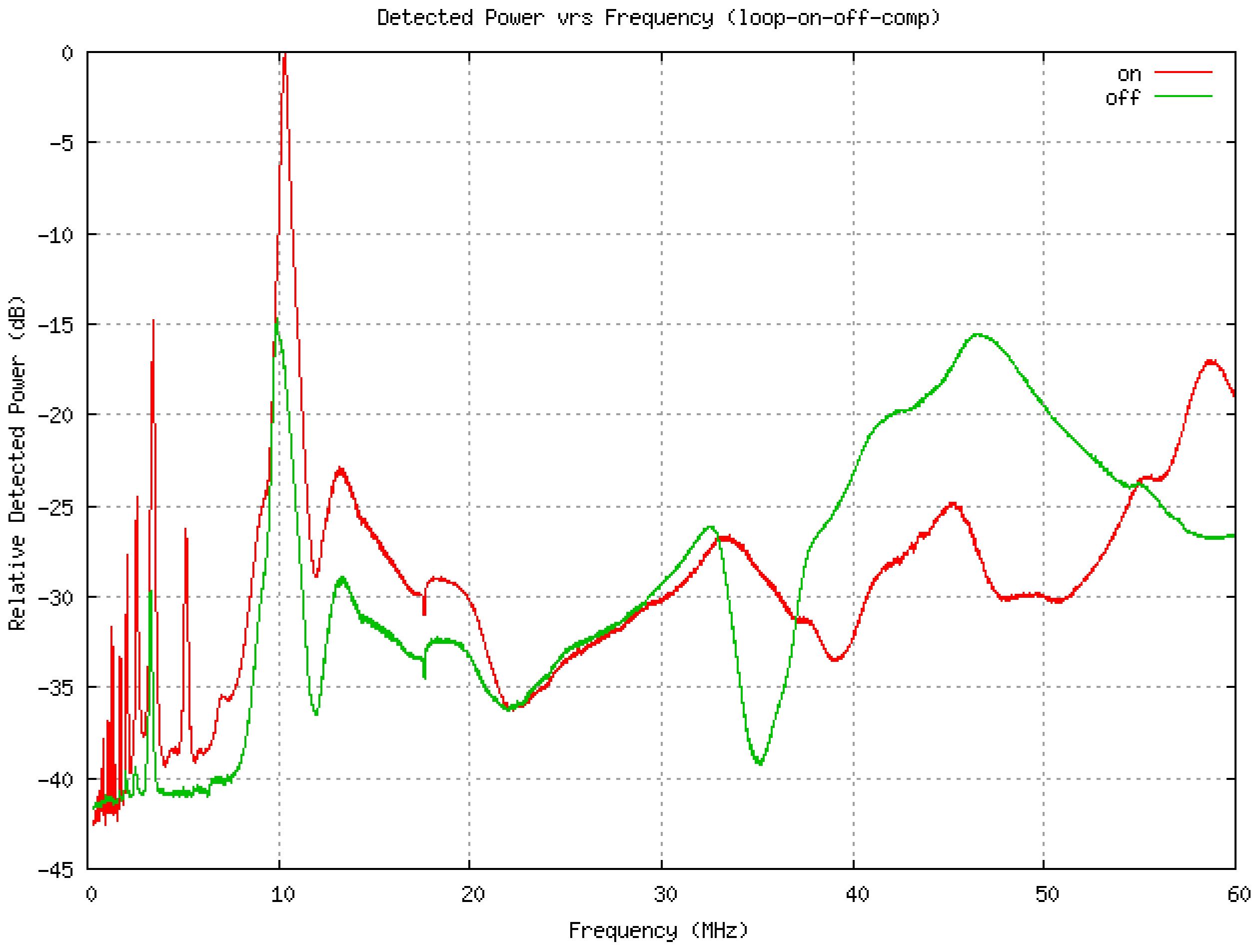
More detailed investigations were made by sweeping the unit with the same experimental scalar analyser used to test the bias-tee. Exact amplitude measurements made in this way are fairly meaningless, as the coupling loop is not well matched to the generator. 10 dB of padding was placed between the coupling loop and the generator but as the loop was placed almost orthogonally to the antenna loop to provide weak coupling (for Q estimation) the coupling loop does not see much of the antenna loop loss resistance.



The loop tunes 7.23 MHz to 12.32 MHz with the polyvaricon used. The apparent loop Q drops with frequency, being 55.6 at 7.23 MHz, then 33.3 at 10.33 MHz and 28 at 12.32 MHz. The loop inductance is about 4.1 uH so the input impedances which match these Qs are 10 kΩ, 8.8 kΩ and 8.9 kΩ respectively. Wider sweeps show problems with the test set-up, in particular generator harmonic energy when tuned below the loop resonances. Neither sweeps have me feeling very comfortable about the quality of test set-up (or the loop construction for that matter). The HF feed-through is probably due to the unshielded housing of the buffer amplifier and stray circuit capacitances. Maybe a LPF should be added to the output to suppress these responses? A HF receiver should reject them with no dramas, but the number of hints of internal resonances and general "complexity" of the baseline above and around resonance doesn't make me too comfortable.



When the amplifier is left unpowered the loop leaks through RF at a lower amplitude, and the resonance is shifted down in frequency somewhat. This is immediately apparent when you connect a receiver to the loop, even without powering it on you can peak-up the background noise level by tuning the polyvaricon. However once power is applied the loop must be retuned (up somewhat) for maximum background noise. Loop Q is degraded quite significantly in the leak-through mode, with Qs of 39.3, 17.1 and 9.1 for the test frequencies discussed above. Loop Q in general could be improved by weaker coupling to the JFET gates, some simulation could optimise the values required if the resonator usable Q was measured and the FETs well characterised. Noise figure would be compromised by resistive DC gate biasing, maybe use chokes?



On thing I initially found rather disturbing about this particular sweep is the 2nd harmonic peak is absent from the "off" run. The 3rd harmonic peak is 15 dB different just as the fundamental is - but the 2nd harmonic "on" signal is smaller and 15 dB down from its level is into the -41 dB "leakage floor" we appear to be observing... All was revealed when I considered that the reference level here is about -12 dBm meaning the leakage is around -53 dBm, quite likely considering the unshielded nature of the amplifier in close proximity to the coupling loop.

Field Testing

For real RX testing I lashed-up the antenna on the balcony, mounted a little above railing height, and A/B compared it against the base-loaded vertical I use for QRSS transmission. This is *not* a very fair test, as the vertical is 3 metres tall, while the loop is less than half a metre in diameter and was mounted at the base of the vertical. Also, interaction between the antennas was *not* controlled during the experiment, and experience has taught me this is critical for meaningful results.

The loop is largely limited by its aperture (cross-section). Compared to my loaded vertical it is about 6 dB down, making it ineffective for its original design purpose (improving my QRSS RX noise floor). However, unlike the omnidirectional vertical it has well defined nulls which are useful for avoiding local interference. The nulls do help dodge some noise, but unless I make it larger or mount it higher the loop is simply not as good for QRSS RX.

For comparison purposes I have built a much larger passive tuned loop antenna. The square loop is root-2 metres on a side in a diamond configuration (for mechanical simplicity) and is matched to the coax using a ferrite transformer placed near the polyvaricon that tunes the loop winding to resonance. It was not possible to fit the loop in the shack for Q-determination and hence the matching is at best an educated guess. Its Q is likely dominated by whatever the receiver input impedance reflects into the loop tank through the matching transformer. Experiments continue, comparing the three antennas for relative performance. More experience and additional test instrumentation is required before fair comparisons can be made.

2 comments.

Attachments

title	type	size

Active Loop Circuit Diagram Source	application/postscript	13.671 kbytes

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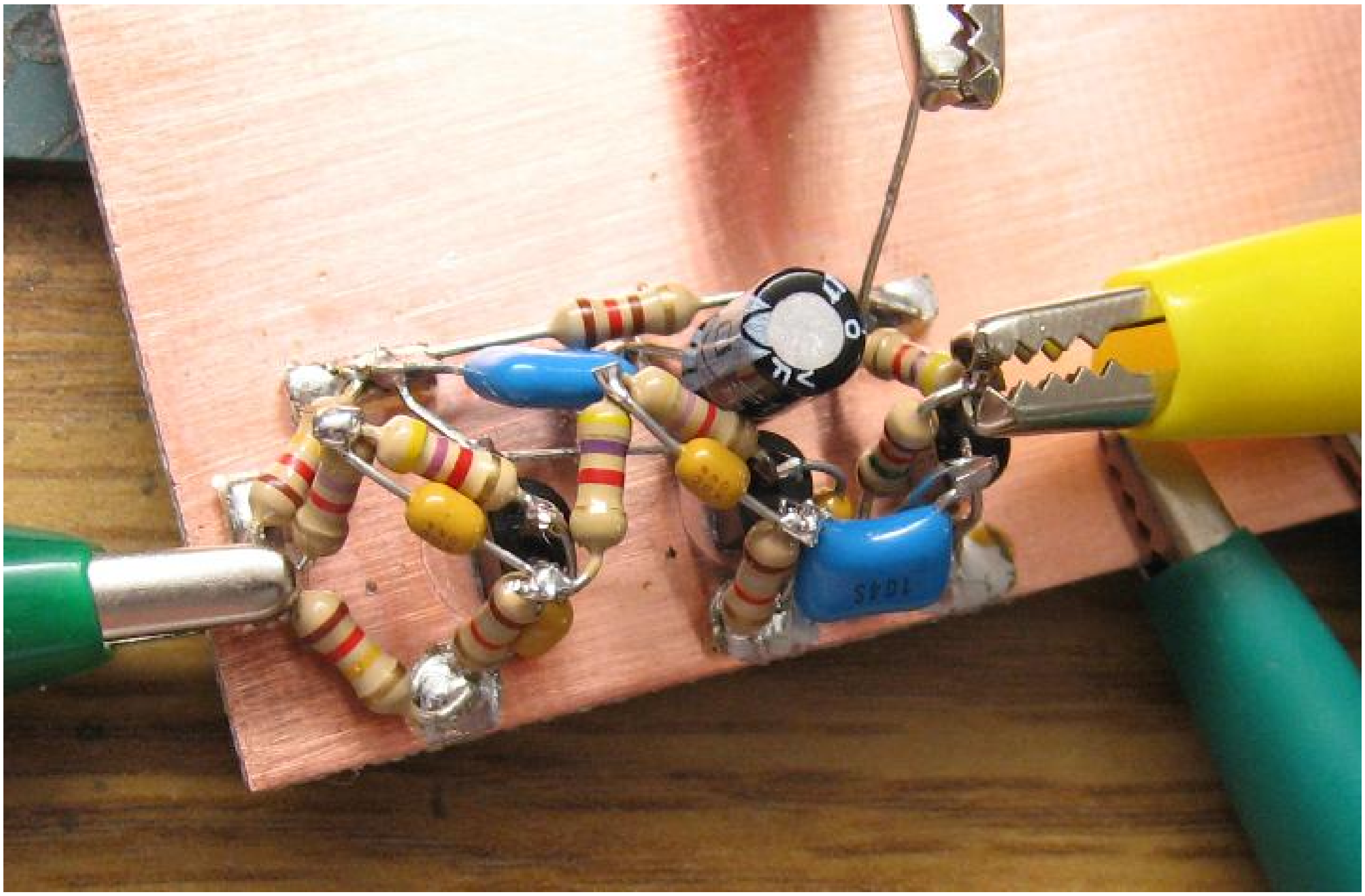
RF Remote Control Experiments

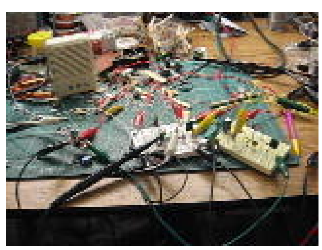
2008-03-29

Some time ago I tacked some LM567 Tone Decoder chips onto a Futurlec order as almost an after thought. I've always wanted to play with them, but it wasn't until Friday night that an immediate use jumped into my head. Like so many of my experiments, the sudden realisation of what I could achieve with them totally derailed the other work in the experimental pipe line, and re-purposed it towards this.

I did give me an excuse to finish building the quench filter and AF pre-amplifier module, as is was needed for these experiments. It comprises of two cascaded Sallen-Key low-pass filters set for about 3.2 kHz and a common emitter pre-amp.



The TX and RX modules from the previous 11 metre AM transceiver work were a perfect test bed for the the tone-coded RC prototype. Basically I lashed up the TX with my signal generator as an AF source and the RX with some filtering to feed the LM567s. Quickly enough I had a LED lighting up when I keyed the transmitter.

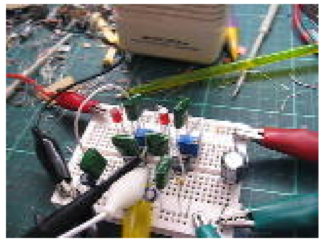


Initial Remote Control Lash-up
(6.107 Mbytes)

 XHTML | CSS | CSS toggle

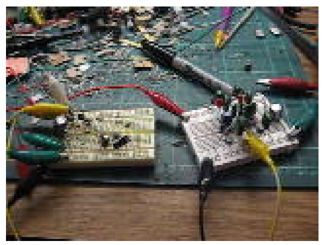
The LM567 can sink about 100 mA, so quite reasonable loads can be switched by it. Unfortunately its saturation voltage is fairly high, but it can directly switch small motors with some snubbers to protect it. A 5.9 Volt motor from a CD player I recently ratted was fitted with an eccentric weight (an aligator clip on the shaft) and rapidly provided remote controlled vibration amusement. The most obvious application is some kind of RC robot, but before I got ahead of myself to achieve that I needed at least two (and better four) channels, and would eventually need to work out a H-bridge to drive more non-trivial motors with some logic to prevent glitches shorting the rails, etc...

A pair of LM567s were wired up on the protoboard and multi-turn trimmers used to align them to separate, but closely spaced tone frequencies. The signal generator swept through their lock ranges and operation confirmed.



Two Tone Decoders Test
(2.147 Mbytes)

I still needed to prove the circuit would work with the two channels concurrently, but to do that I needed to build two AF tone sources. A pair of phase-shift oscillators where built, and after some number-crunching and buffering hell I had a suitable two-tone signal source for modulating my TX. This is basically frequency division multiplexing. Having proved the RF system at this point I dispensed with it for the remainder of the tone generation and decode work, favouring direct connection through a suitable attenuator while stabilising the design.



Concurrent Tone Test
(4.150 Mbytes)

Now quite happy that two concurrent channels would work (not too surprising as DTMF decoding is an application hinted at in the datasheet - hopefully I can do four with still sufficient IMD/HD and noise margin), it is simply a matter of building the circuit in a more permanent form and tackling the (typically harder for me) task of the mechanical side of a robot of some description.

When I've got all this nutted out I'll post the circuit diagrams of both the voice walkie-talkie and the remote control (and whatever it ends up controlling).

3 comments.

Alan's Lab

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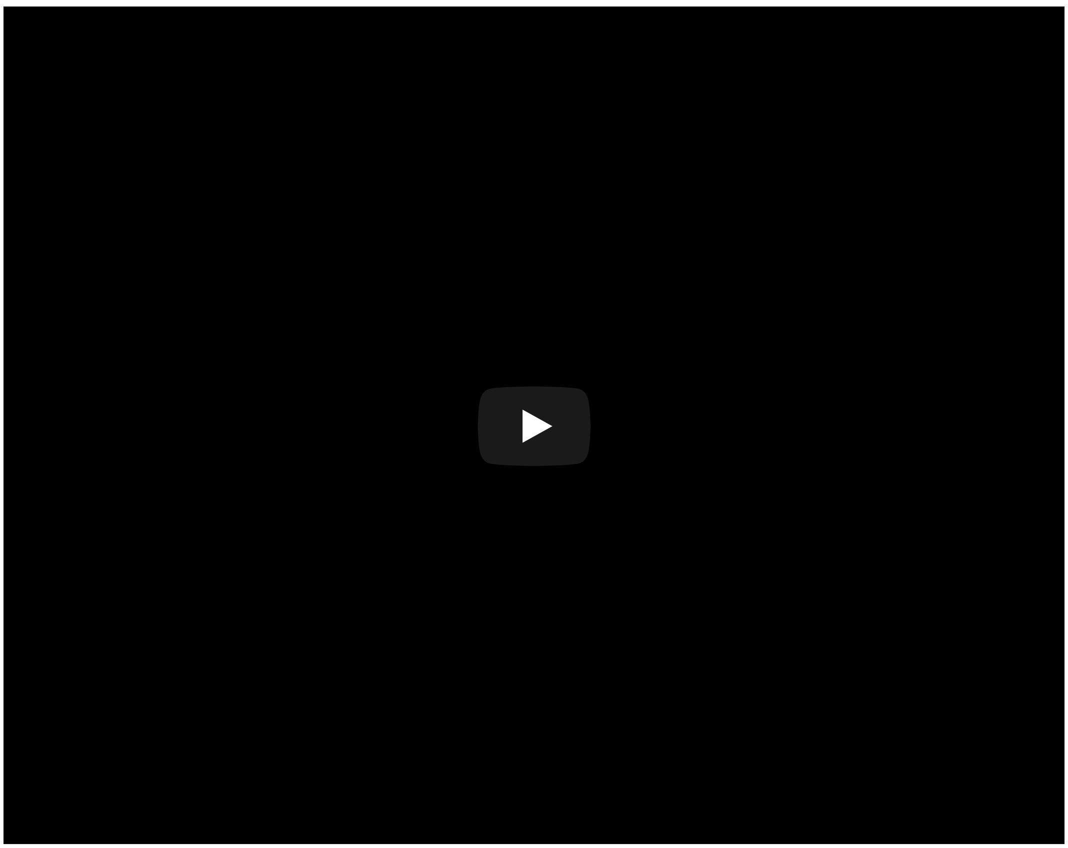
Wireless Power Experiments

2010-12-26

Along the lines of the season's traditional blinkenlight projects I had the desire to build a rotating persistence of vision display of festive geometry. The usual problem of delivering power to the rotating bus from the static part was the first engineering challenge. Most builders avoid this problem entirely by putting batteries on the spun bus, or by using slip-rings (often in the form of a 3.5 mm audio jack and socket). One inventive idea I've seen is to steal power from the motor armature but this requires removing one of the motor bearings. I decided instead to try sending power to the spun bus wirelessly - an engineering solution which incidentally also solves two other problems intrinsic to the design of spun displays - more on that in a later article...

Some Talk

First lets talk about wireless electrical power transfer. Here is a lengthy video I made on the subject, covering the basic physics and the technical difficulties of achieving high efficiencies. It covers much of the material of this article and can be watched instead of reading the article, or in addition to it. The video, much as this article, makes many simplifying assumptions as doesn't talk much/all about source impedance, matching, the electric and magnetic properties of matter (dielectric and hysteretic losses). Neither do I provide a design procedure, rather I give a rough sketch of the critical parts of the system you need to look at closely if designing your own.



Induction, Transformers, Mutual Inductance and Coupling

For the original display project it would be a simple matter to build a rotary transformer and send power across a small gap, but doing so requires great mechanical precision. Conventional power transformers achieve high efficiency because their closed magnetic circuits give good coupling between the primary and secondary inductances, minimising their leakage inductance. Good magnetic coupling between the windings in a rotary transformer means minimising the air-gap in the magnetic circuit.

A much more easily hackable solution for my toy display is to use so-called "evanescent wave coupling" to send power between tuned resonators. This allows efficient operation at much weaker coupling (much larger air-gap and/or no magnetic core material at all), as long as the resonators are fairly high-Q (low loss). Essentially we allow the much larger leakage inductances associated with low inductor coupling coefficients of "air core" transformers and then tune them out with capacitance, utilising the remaining mutual inductance to transfer power between the resonant circuits. In effect we utilise the large "buffering" capacity of high-Q tuned circuits to render an impedance match from the TX power source into the RX load over a poorly coupled path. As long as the inductors are physically small with respect to the free-space wavelength of the frequency of operation very little radiation (leakage of energy into space as radio emissions) will occur.

Yes, Tesla had this idea working in 1893, but there are a number of practical issues that limit the technique to niche applications, such as toothbrush and cellular telephone chargers where the coupling coefficient can be kept high, placing less demands on the circuit components, especially inductor Q. Sending power significant distances of free-space without radiation demands very high-Q as inductor

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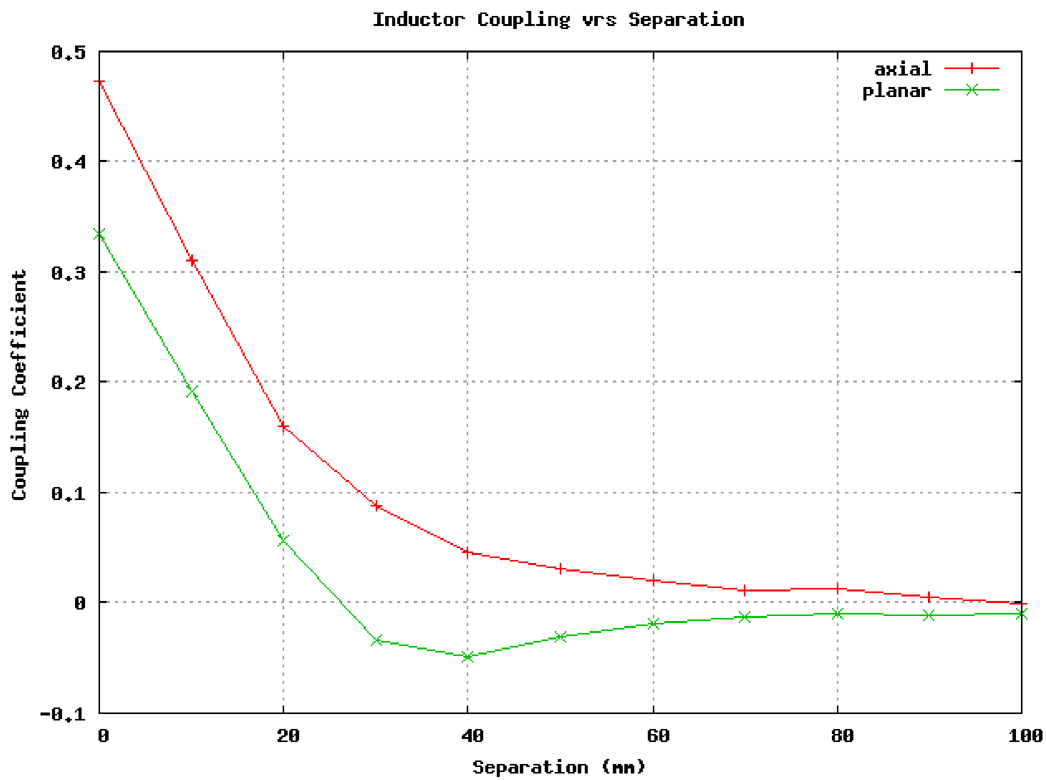
become large with respect to the reflected load impedances seen "across the gap" from the secondary to the primary, efficiency drops rapidly unless resonator Q is increased to keep loss small with respect to the actual useful load dissipation. There is an almost linear relation between the product of inductor Q and coupling coefficient (denoted k) and the total system efficiency (n). As k drops Q must be elevated to maintain the same system efficiency, basically n ~ kQ. With practical inductors, Qs over 100 require special and expensive techniques to achieve, so most implementations of wireless power transfer try to keep coupling as high as possible. Inductor coupling basically comes down to proximity and alignment.

Inductor Coupling

To get a practical feel for inductor coupling coefficients, I performed a simple experiment. I wound a pair of planar ~4 uH coils on ~50 mm OD former using 700 um magnetic wire. Coupling was assessed in face-to-face (axial) and edge-to-edge (planar) placements at spacings up to 2 diameters. You can perform this experiment yourself; measure mutual inductance, and hence coupling coefficient by measuring the individual self-inductances of each coil and the total inductance of the coil pairs in-phase (or anti-phase), the difference is twice their mutual inductance. Their mutual inductance is the coupling coefficient times the geometric mean of their individual self-inductances.



You'll note that axial alignment offers the best coupling, and that coupling actually goes through zero and becomes negative with planar alignment. (Negative coupling means phase reversal; picking up more flux from the other side of the coil, for power transfer purposes phase is irrelevant and we care only about the magnitude of the coupling coefficient).

If you try this with different sized coils you'll find the coupling always drops rapidly below 0.1 as you separate the coils by more than a diameter or so. This means to keep a high coupling coefficient over distance you need big antenna coils. It is instructive to repeat the experiment with one large coil and a much smaller diameter one - as would be the typical case of a practical wireless power system - the coupling is weaker again. Coupling also varies with coil alignment, placed orthogonally coupling plummets almost to zero, indeed you can completely null the mutual inductance between coils by suitable placement. In a power transfer system such an alignment would deliver no power to the load.

Inductor Losses and Q

High-Q inductors are best made by using thick wire (large surface area), space wound with a length to diameter ratio of the overall coil of somewhere between 1 and 2. This optimal length/diameter ratio comes from ohmic/skin effect loss minimisation and inductance maximisation (wire length vrs coil geometry), combined with the need to space-wind to minimise proximity effect losses. Unfortunately this optimal shape is not a very convenient shape for practical wireless power systems, especially as diameter must be large to allow large coil separations and maintain coupling efficiency. Wireless power system resonator inductors are therefore a compromise between coupling, physical form, and Q/efficiency (and material cost).

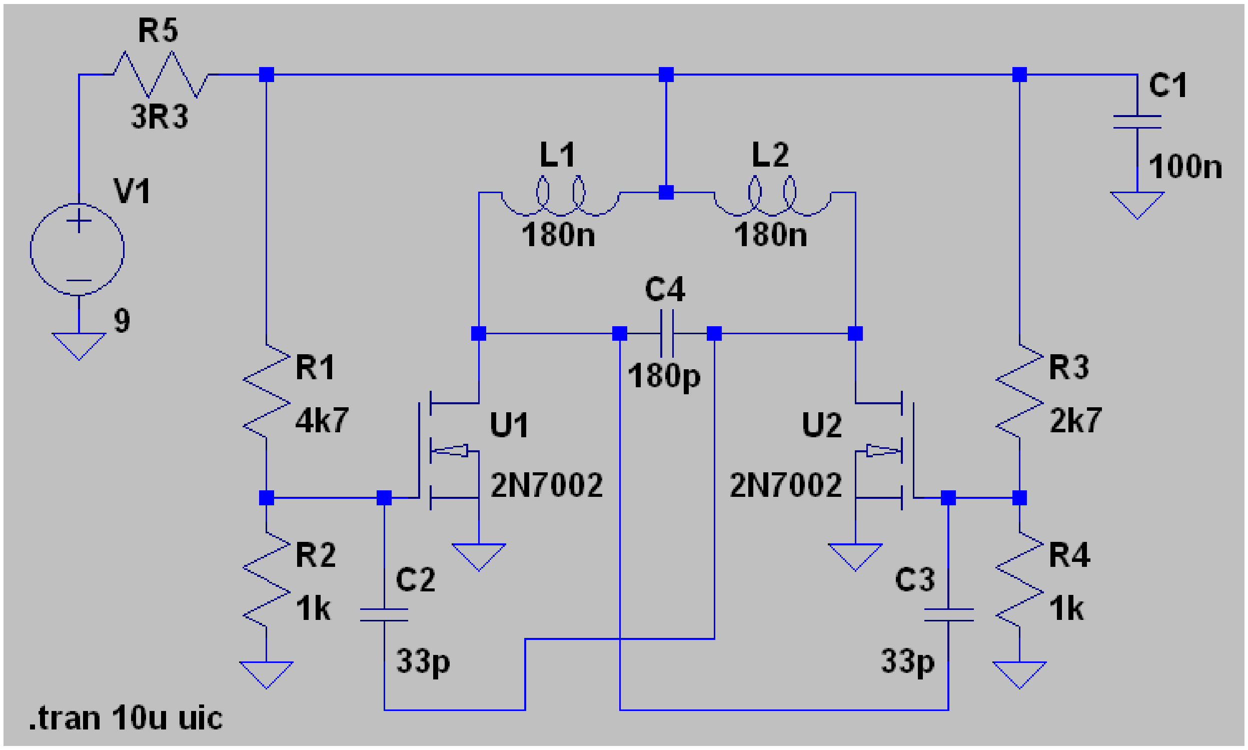
Before continuing to just hack away on the bench, I did some modelling on paper and simulations in LTSpice to get a feel for the key design problems. Resonator Q is critically important for high efficiency at low coupling. The TX-side antenna Q is in some ways more important, ideally there should be relatively large circulating energies in the resonator with RX-side loss (power transfer) being seen as additional loss only on demand. Of course the RX antenna is important too, but the TX antenna is always powered, better Q means it wastes less power when not loaded. You can think of the system as a double-tuned band-pass LC filter with very weak coupling between the resonators. Insertion loss is related to resonator unloaded Q and system bandwidth (loaded Q). The narrower you make the pass-band the more loss you experience due to finite resonator Q, but the weaker the coupling you need - and also the more accurate your tuning needs to be... Maximum transfer efficiency occurs only for one resonator loading (selection of loaded-Q for optimum power delivery given all system properties).

This basic physics of the required resonator tuning and coupling is one of the main reasons "Witricity" hasn't seen widespread adoption. Some claim to have systems which dynamically optimise either or both ends of the system, but it is quite obviously a nasty engineering

to the TX antenna, differing couplings, practical Q for a low-cost implementation, etc. Fortunately it is a fairly tractable problem if you just want to send a watt or two across a few inches and aren't too fussed about perfect efficiency. Charging "mats" are very practical and can operate at k in the region of 0.1-0.4 for practical geometries and implementation costs.

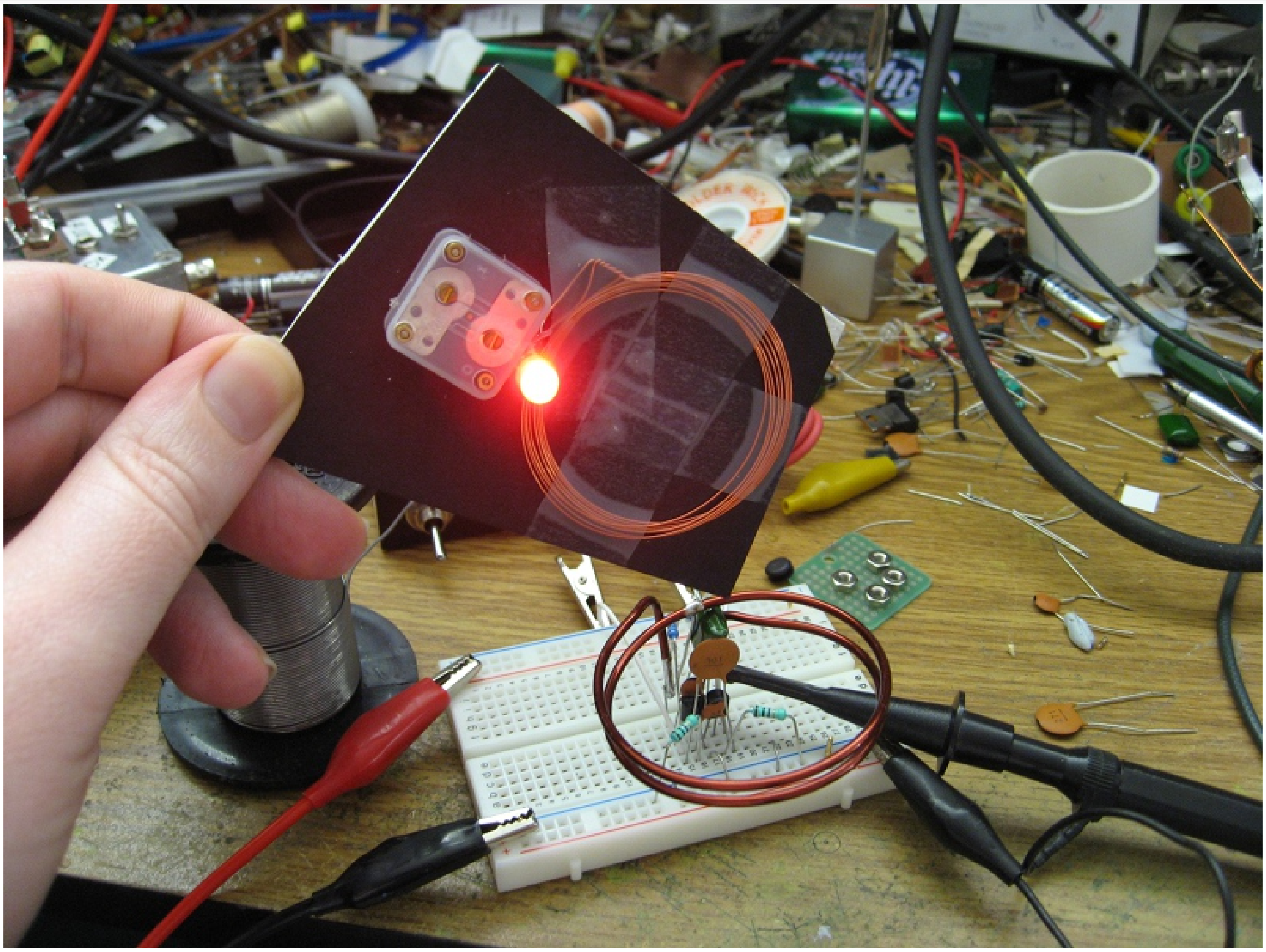
A Simple TX for Experimentation

OK, so back to practical stuff on the bench. I breadboarded a simple push-pull power-oscillator using a pair of 2N7000 MOSFETs, operating in the HF region. (I've attached an LTSpice model if you want to tinker with it, I used a 2N7002 model and asymmetric bias resistors to keep spice happy, the real circuit uses 2N7000s and starts just fine with 4k7 bias resistors on both sides.)

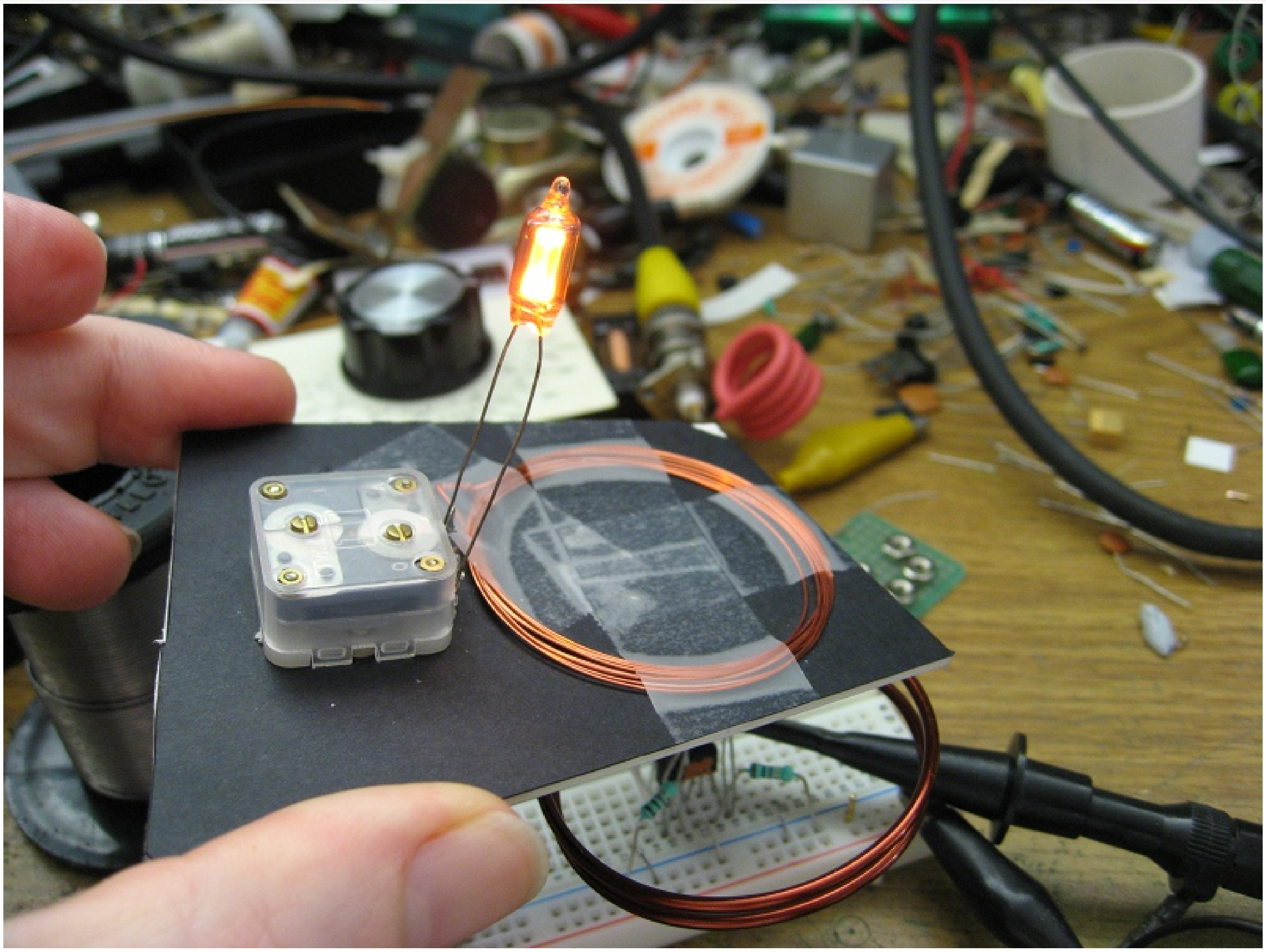


The "180p" capacitor tunes the tapped coil to the frequency of operation, select or make it variable as desired. In one implementation I put 6v8 zener diodes on the MOSFET gates to protect them against over-voltage destruction, at low powers this is not strictly needed, but at higher powers you may need them. Similarly the pair of 33 pF feedback capacitors need to be selected with the frequency of operation in mind. The MOSFET drain breakdown voltage is also important if you are trying to scale up this circuit. While simple, other approaches are probably better for high powers, the MOSFETs are spending a lot of time in their transition regions, dissipating a lot of power. A purely switching class-E approach is obviously better, but suffers from sensitivity of tuning to load impedance in my brief experiments with it (using an IRF510 device). (I've attached another spice model attempting to show the class-E TX approach, I started with values derived using my class-E power amplifier design calculator, as shown it is not perfectly tuned. The practical circuit tunes up nicely and is quite efficient > 70%.) The breadboard TX in the video above is a class-C version with weak capacitive coupling to the tank to optimise its Q. Yet another approach is half or H-bridges, these show great promise, perhaps driving a magnetically coupled "link" winding rather than the tank directly, allowing the tank to float, and facilitating easy variation of coupling to it to optimise its Q... A subject for more detailed investigation at a later date perhaps.

Anyway, combined with one of my LC tank jigs I was lighting LEDs and Neon bulbs over a few inches within minutes of breadboarding the simple push-pull prototype.



The NE-2 bulb demonstration is instructive. Without much of a load, the voltage across a tank in the near-field of the TX rises to enormous levels at resonance. A load dump with a sensitive circuit in the RX might be disastrous unless you anticipate this effect.

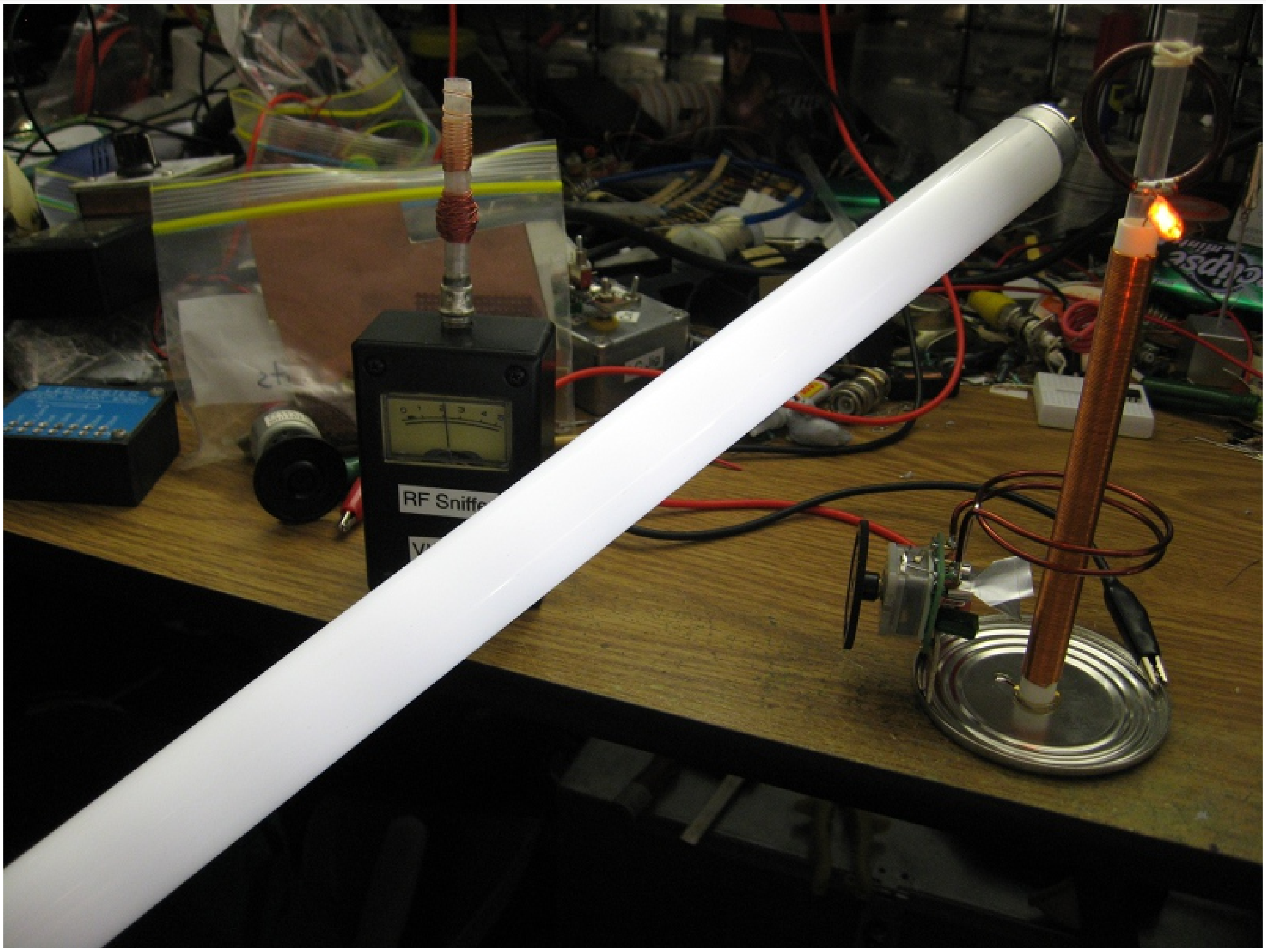


This combined with the LED example also demonstrates the simplicity of a "shunt" regulation approach, the LED clamps the resonator voltage to only a few volts where as with the NE-2 bulb the tank can swing about 60 volts before the Neon ionises. The resonator Q is degraded much more by the LED, reducing the power transfer and offering some regulation. The Neon bulb was dissipating about a watt in comparison because its higher impedance load allows more efficient power transfer. One can tap-down on the inductor (either physically or electrically using tapped capacitance or other matching techniques) to improve the "match" and power transfer efficiency to lower impedance loads.

In a practical charging system rectification of the RF waveform costs you a lot of voltage, so it is important to use low drop, high speed diodes (Schottky for example) and ideally a bridge topology. (Yet another spice model is attached containing a rather non-optimal but very simple end-to-end system including bridge rectification.) Voltage regulation would be efficiently implemented using a modern switching regulator, but clearly the system needs to be designed to deliver sufficient voltage at the expected couplings to operate the switching regulator (which may then boost the voltage if required, perhaps bootstrapping itself also). Total available power is optimised by tuning the entire system to make the load match the source, and using very high Q components to minimise the system losses. In practice your resonators will have hundreds of volts across them with large circulating currents even just delivering milliwatts into a well-matched low-voltage load. This is why their losses are so very significant.

A Cute Tesla Coil

Naturally enough it is hard to not think of Nikola Tesla and Tesla Coils when doing this kind of work. It wasn't long before I wound a long-thin secondary with a self-resonance of about 21 MHz. As Tesla coils go that is an rather high frequency, but it works quite well. This cute little Tesla coil is limited by the 2N7000s of the power oscillator to about 1.8 watts, but produces a very strong electric field, the amplitude of which is sufficient to light fluorescent lighting tubes and neon bulbs.



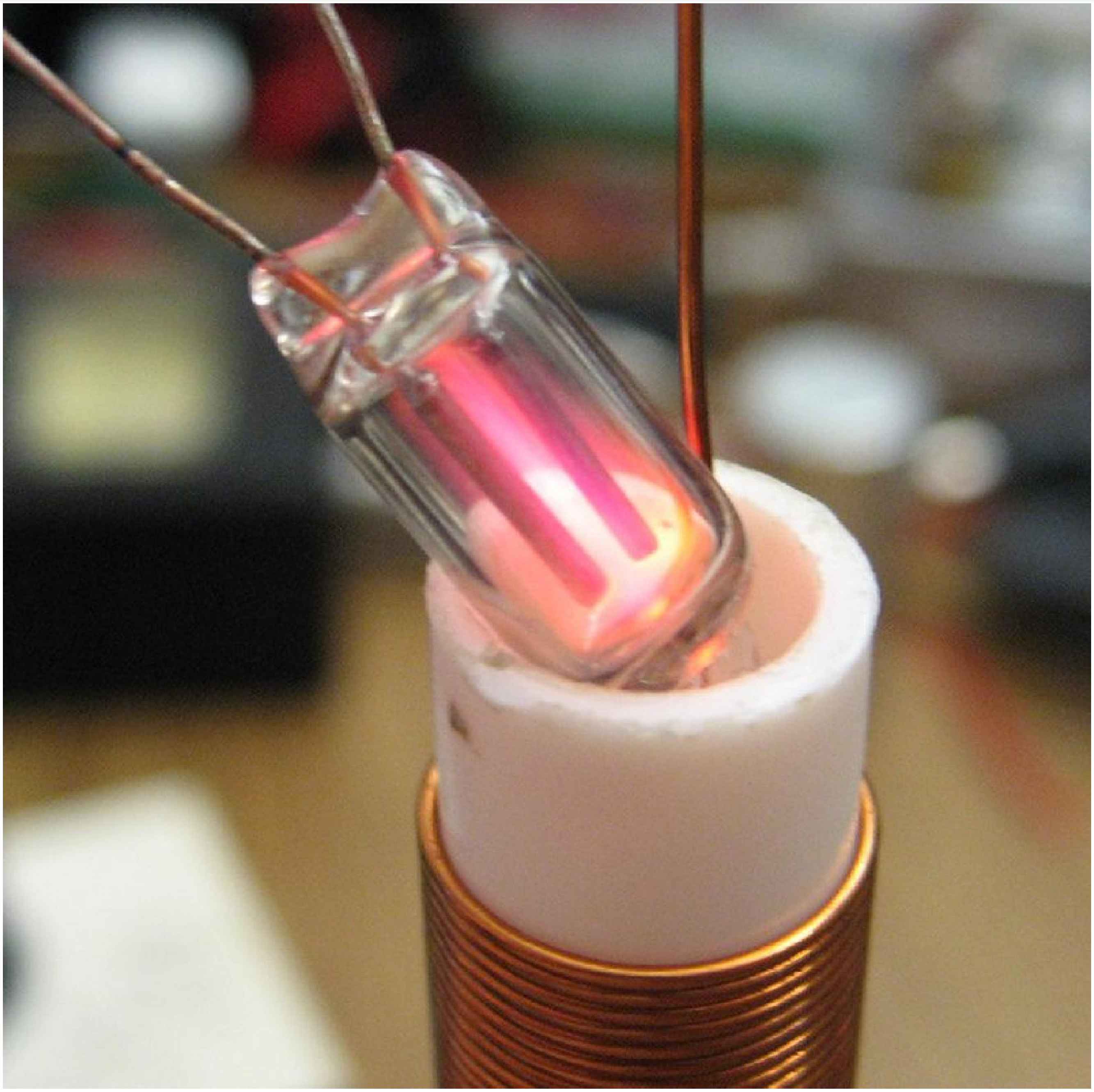
The circuit is dead-simple, but the simplicity has some limitations. The power oscillator needs to be tuned to the secondary resonance and loading of the secondary can pull its resonance quite a lot - meaning you need to retune it some times. Coupling between the primary and secondary is slightly tight and the oscillator shows a bit of hysteresis-instability tuning across resonance. Still I think I may have to scale this baby coil up to something capable of producing break-out in air! Don't let this teeny coil fool you though, even at < 2 watts it is still capable of giving you an RF burn. The high-Z output can deliver most of that watt or so into an sub-cubic-mm of flesh, energy densities that instantly cook a pin-point of skin - it hurts trust me! Even initial tests using my C-jig and a planar coil of thin wire over the lashed-up primary on the breadboard gave me an uncomfortable burning sensation as I tuned through resonance with no load except my body - the voltages across the resonator are plenty high enough to push significant power through your skin. At higher power levels you will do damage before you can react.

An Aside - Fluorescent Tube Striations

It was while playing with this toy I first observed Fluorescent Tube Striations.

I may have vaguely observed this before, but it never really registered with me how fascinating they are. I had a lot of trouble finding any explanation of their cause online, but it seems to be a plasma physics effect, an interaction between the emitted photons and the electrons in the plasma. I found it interesting that their number was quantised and ranges of applied field would sustain only a specific number.

Another effect I noticed with the Tesla coil was NE-2 bulbs emitting purplish light in addition to their usual orange Neon lines. I need a spectrometer to tell exactly what is going on, yet another area of investigation for a rainy weekend...



Conclusions

My video is all very doom and gloom about the possibilities of generalised wireless power becoming widespread, but it is obvious that non-contact charging is quite practical and even easy to homebrew. There has been some commercial work on wireless charging mats, and a few attempts to standardise frequencies and near-field communication systems for allowing a range of appliances to communicate their needs to generic charging transmitters. Unfortunately a lot of commercial effort currently seems to be being expended in accumulating patents for ambush purposes, waiting for the day when someone finally gets a system to market and accumulates enough share to make it the defacto standard. Perhaps part of the problem is also lack of real need when balanced against the costs of implementation - plain-old copper wire works fine and plugging in a device to charge isn't really that difficult. Many after-market systems require a bulky module to be plugged into an existing device to "enable" it for wireless charging. While this is a natural intermediate, for consumers where is the benefit? Real progress can only be made by adoption of a standard which can be implemented in devices straight from the factory.

15 comments.

Attachments

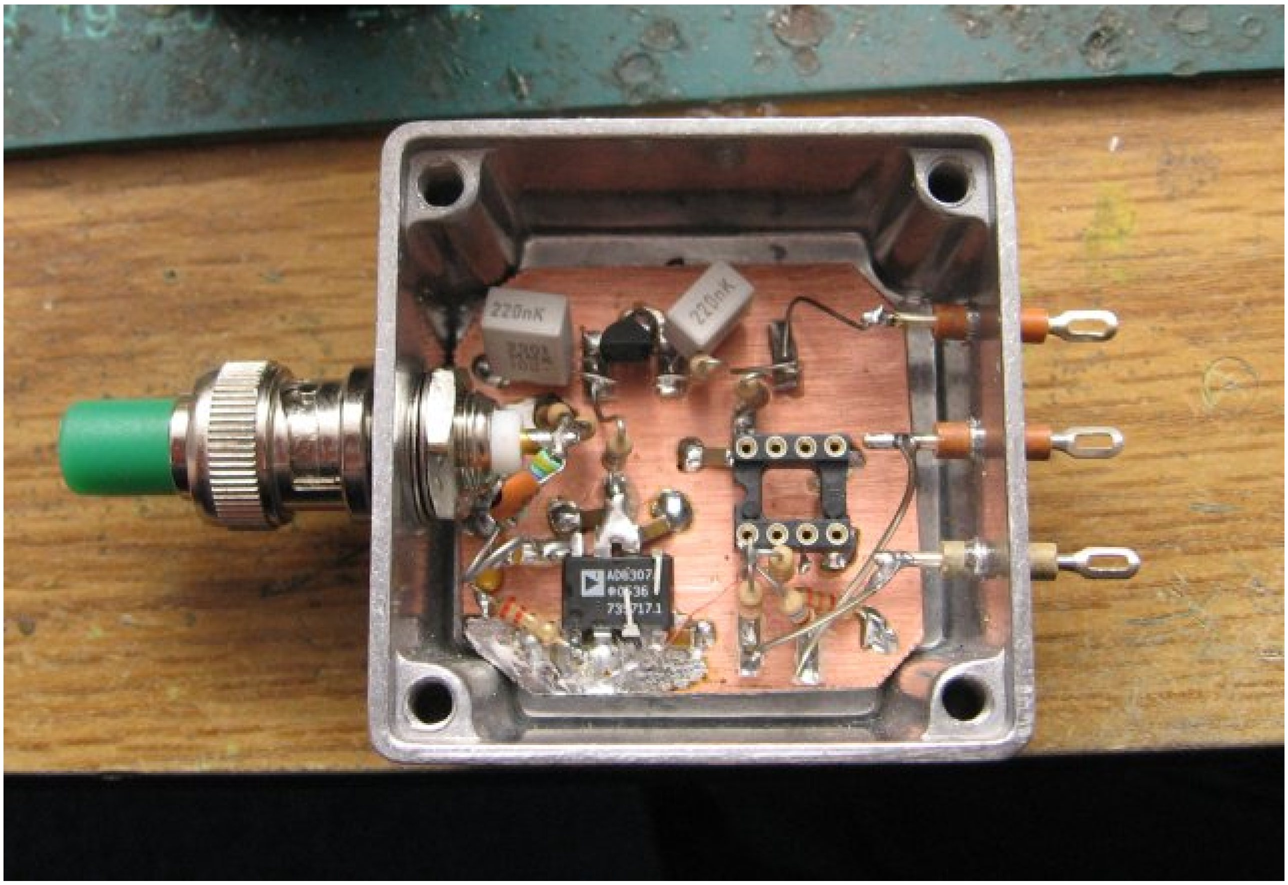
title	type	size
Class-D Witricity Design	application/octet-stream	3.356 kbytes
Simple Witricity Design	application/octet-stream	3.050 kbytes
Experimental Push-Pull TX Oscillator	application/octet-stream	2.151 kbytes

2011-04-26: Wireless Power Demo Circuit
Circuit diagram of the wireless power TX used in the video demonstration.

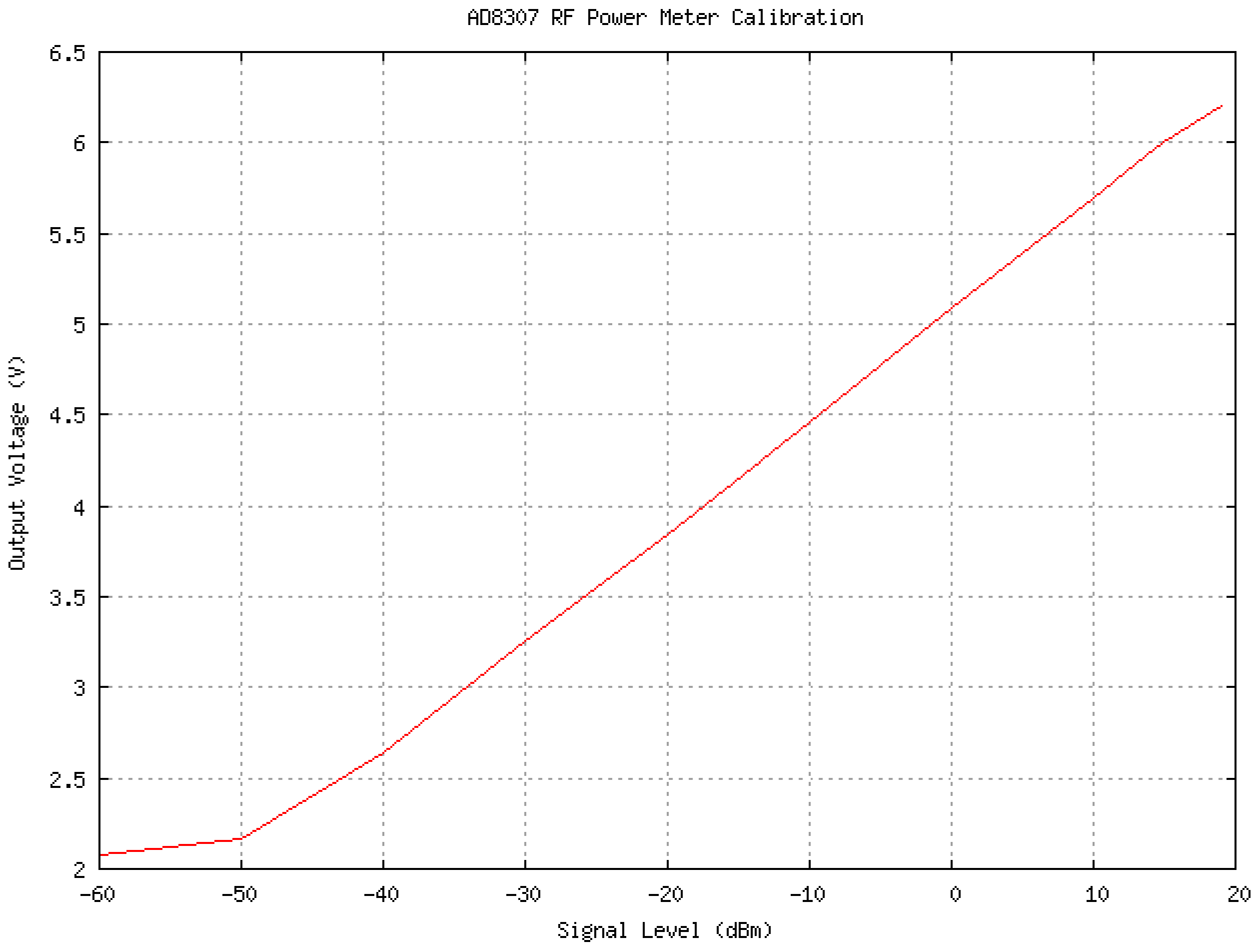
AD8307 RF Power Meter

2010-02-01

At the latest ARNSW Homebrew Group meeting I had the opportunity to finally calibrate my AD8307-based RF power measurement head.



Mark VK2XOF brought along his power and frequency reference equipment and gave me a bunch of calibration points.



Data points above 13 dBm were given using the generator out of levelling-loop calibration so the slight compression approaching 20 dBm is to be expected. The levelling off below -40 dBm however is not. I know the noise floor of the meter (dummy-load terminated) is about 500 mV DC output, -40 dBm is about 2.65 V out, suggesting wideband noise from the generator was swamping the lower level spot calibration signals.

Regardless in between the data is very consistent and lets me compute a "slope + intercept" calibration relying on the excellent linearity of the AD8307. The 0 dBm intercept is 5.09 Volts and the slope is 16.469 dB per Volt (60.7 mV per dB). Based on the 500 mV noise floor this equates to about -75.6 dBm, or about 80 dB dynamic range - as expected for an AD8307-based unit.

Frequency response wise, my use of leaded resistors means it maintains its accuracy to about 250 MHz, which is sufficient for my immediate purposes. The circuit design itself is the W7ZOI design from EMRFD, page 7.7, figure 7.13.

3 comments.

AM Walkie-Talkie Experiments

2008-03-23

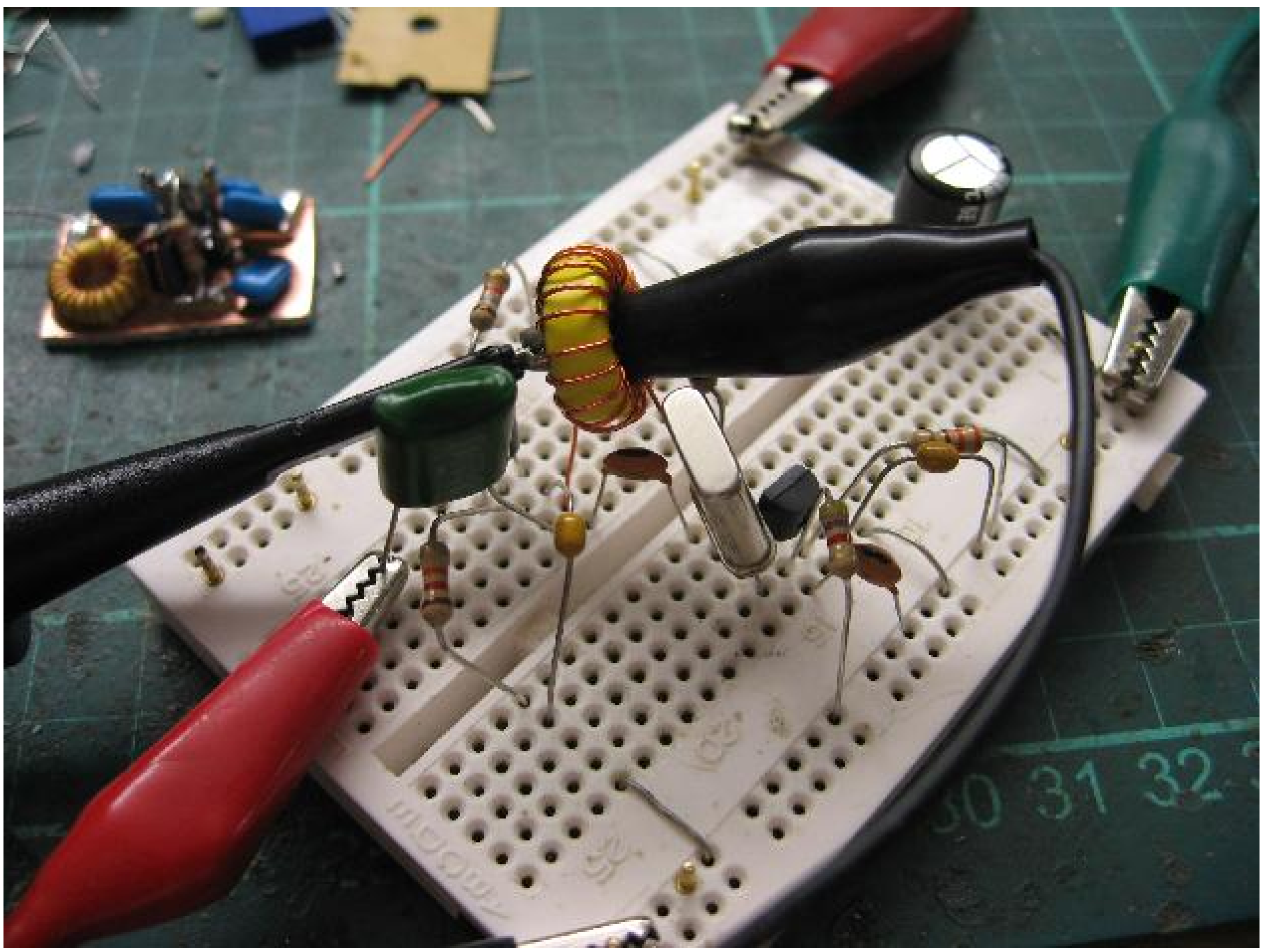
Michael Rainey AA1TJ has been acting as my muse again. He knows of my fondness for minimal component radios and sent me an old Italian article "Il Pigmeo", which features a one-transistor 27 MHz walkie talkie (apparently capable for 400 metres range). Naturally with my high school Italian long forgotten, I couldn't read a word, but the circuit diagram was quite clear.

The circuit uses a 3PDT switch to make one transistor (an OC171) behave as either a collector modulated Pierce oscillator (with a carbon microphone), or a super-regenerative detector feeding a dynamic earpiece through an impedance transformer. The power supply is a 9 Volt battery and the telescopic antenna contains a base loading coil.

The switching did intimidate me a bit. While not a complex circuit and having a bag of 4PDT switches in stock (from a Rockby sale), the switches are unfortunately for rectangular mounting holes and I didn't feel up to drilling and nibbling a neat hole in a piece of PCB just to build a prototype. Instead I built the TX and RX circuits independently to see how well they'd work.

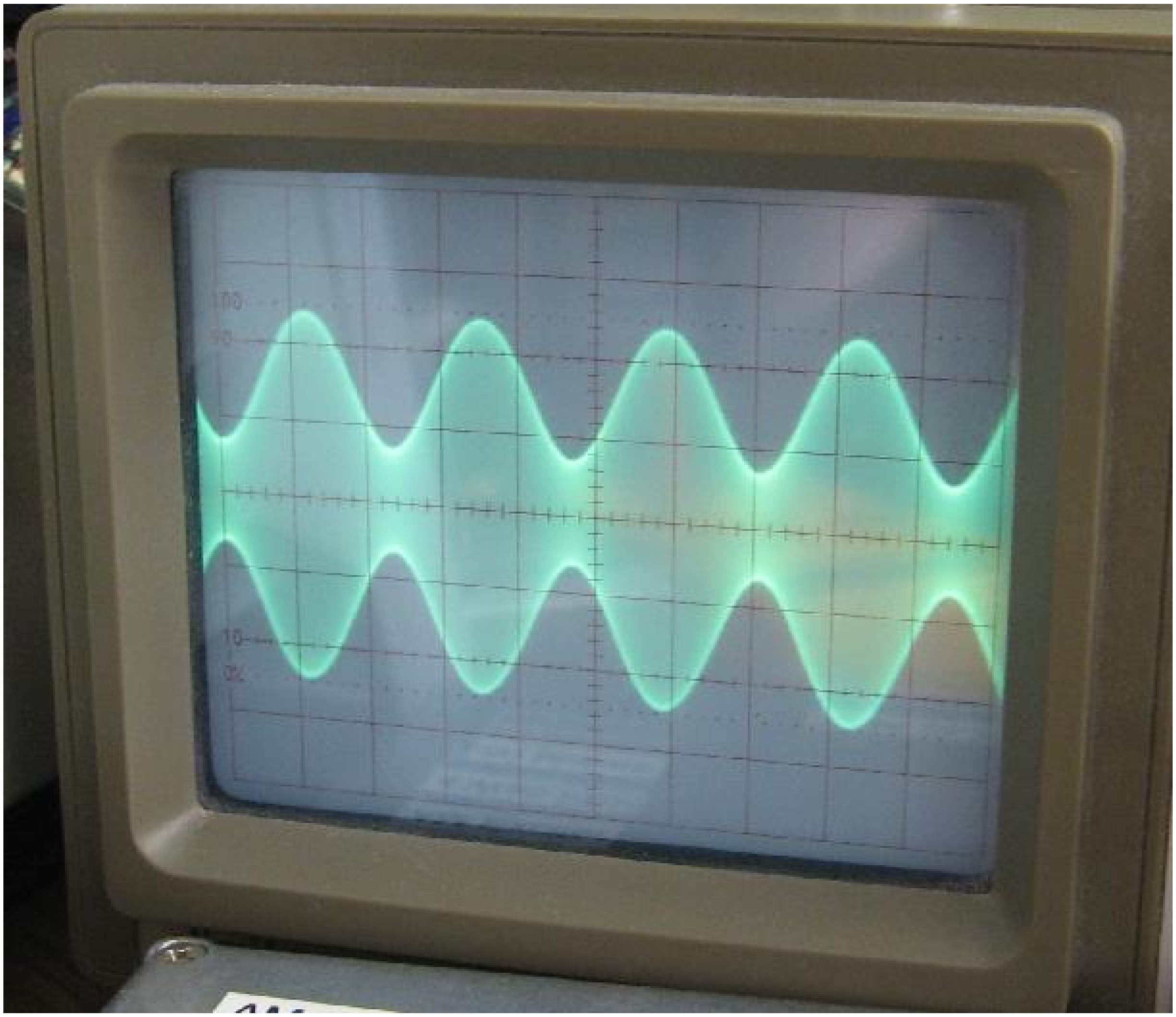
Transmitter

I started with the TX as the receiver looked "odd" and I wanted a nice stable signal source for experimenting with it later. Even just thrown together on a solderless breadboard the circuit worked well - that said, you can't really stuff up a Pierce oscillator.

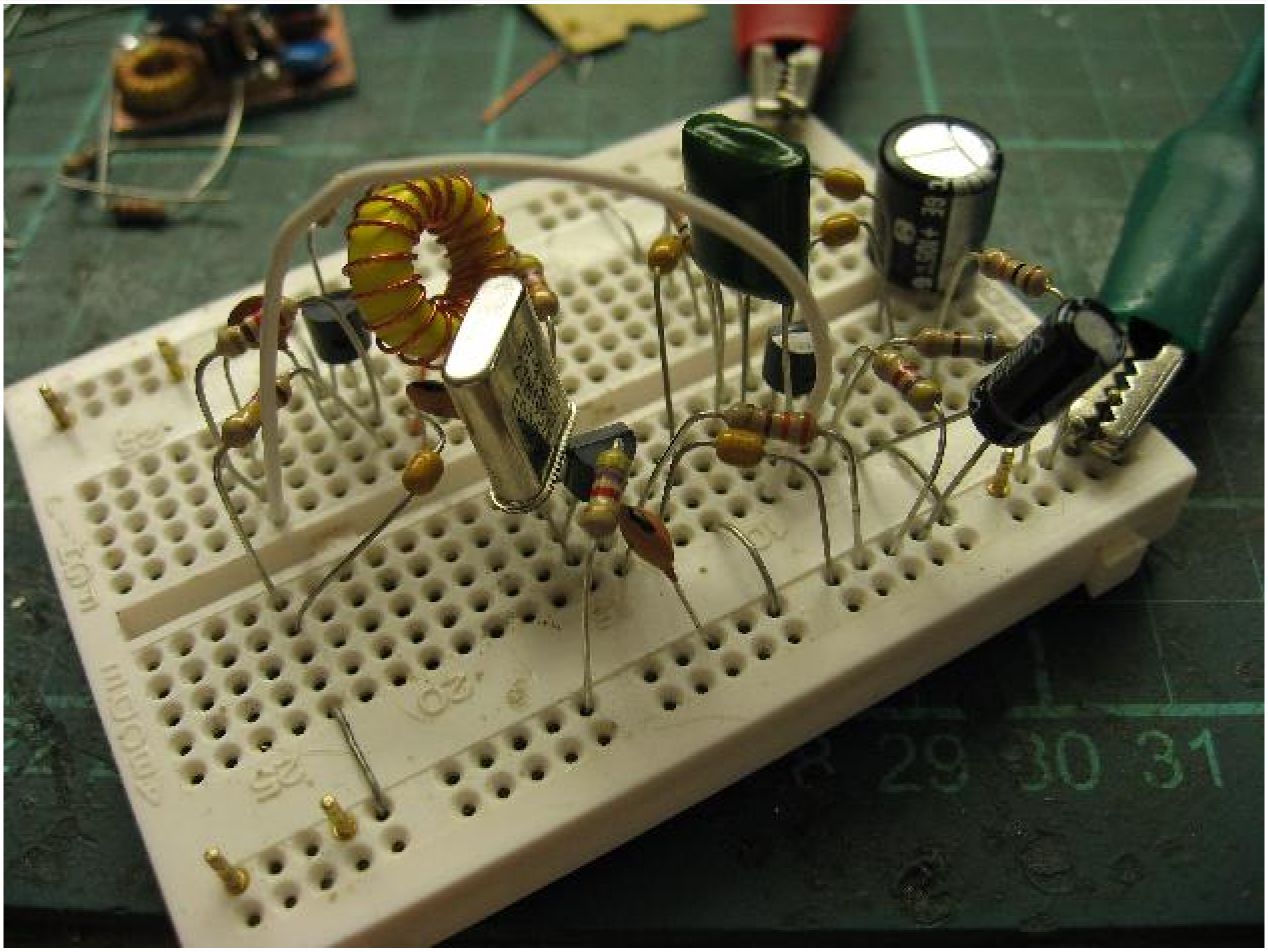


I didn't have a carbon microphone, so I put another transistor in the collector circuit as an emitter follower and

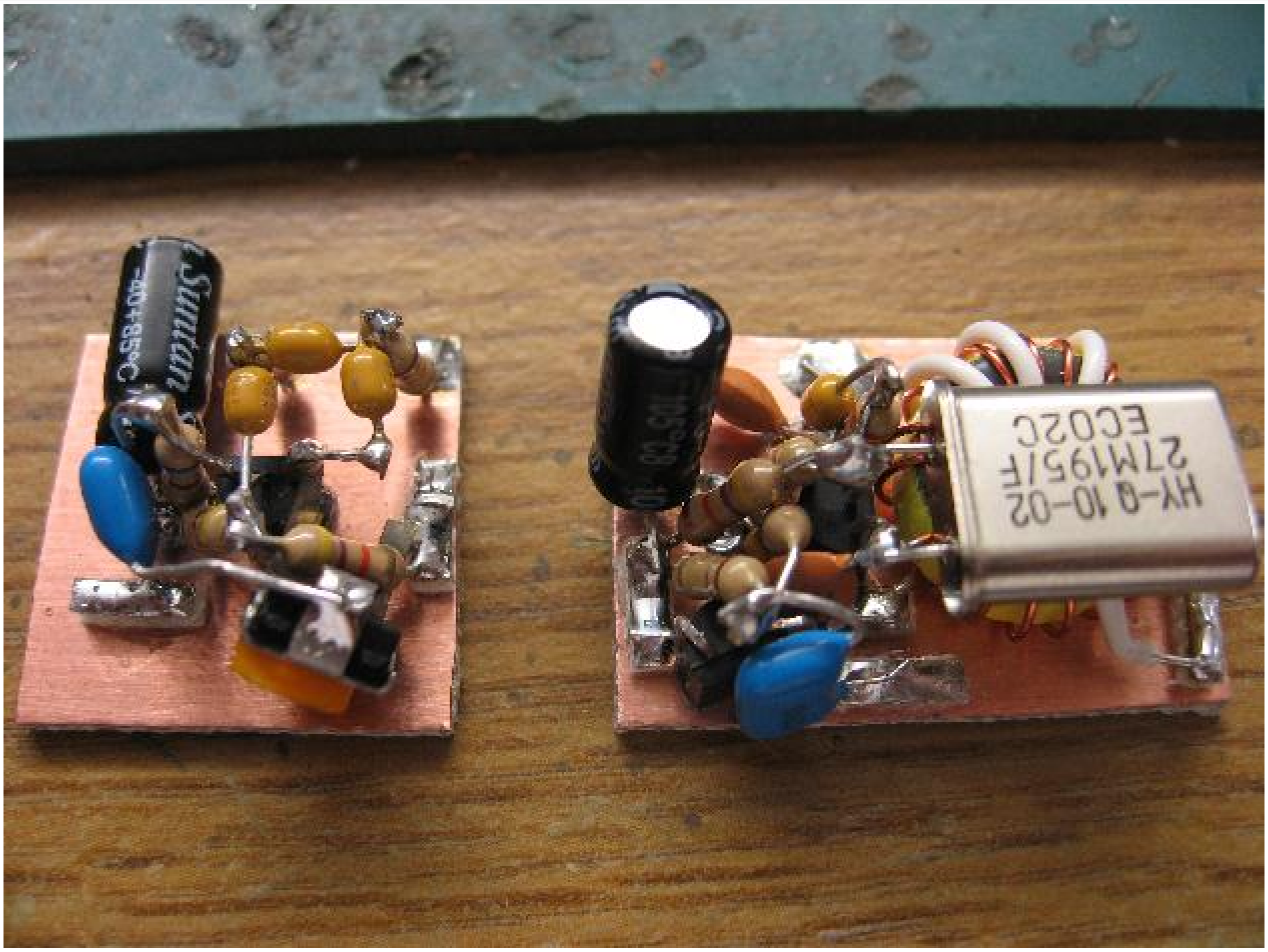
beautiful AM modulation.



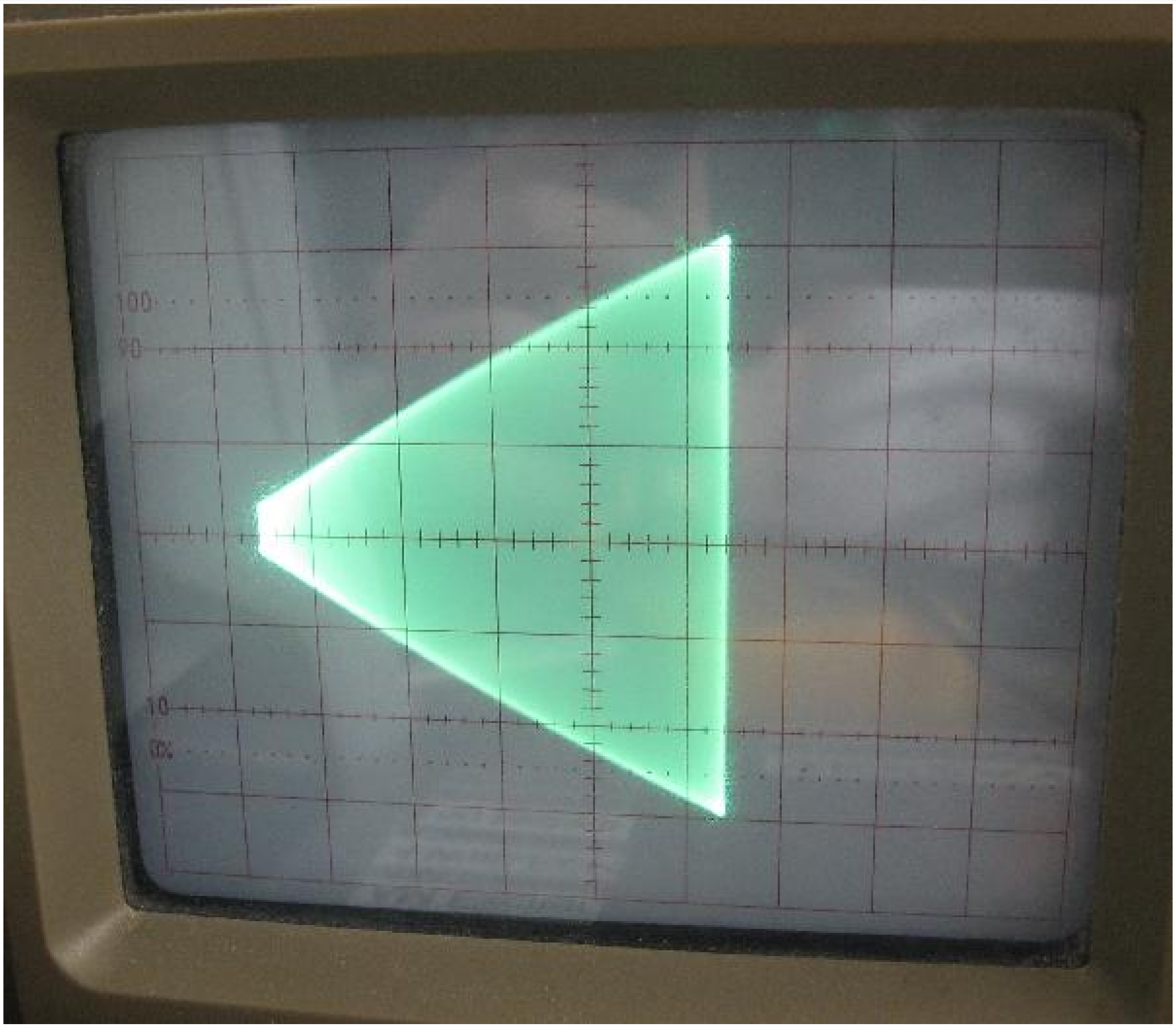
Connecting up to the old VR-500 receiver tuned to 2BL gave me a chance to listen to the audio over the air. Listening on my FT-815 and RCI-2950 proved it was quite a reasonable fidelity TX. To make it a stand-alone test transmitter, I built a phase-shift oscillator to feed the modulator.



This was quickly built into a more permanent version, as two modules, the AM TX itself and the AF oscillator signal source. Each is quite useful in its own right.

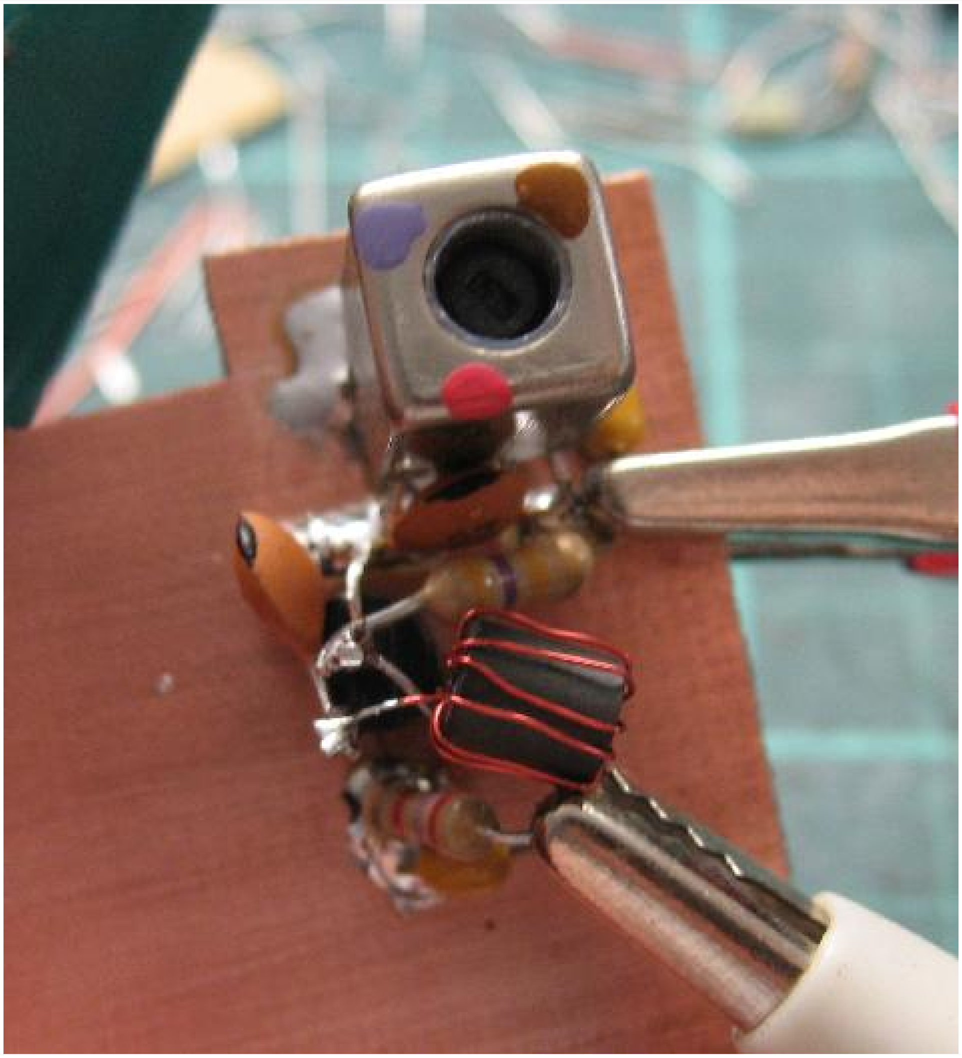


The collector modulation looks wonderfully linear on a trapezoid test



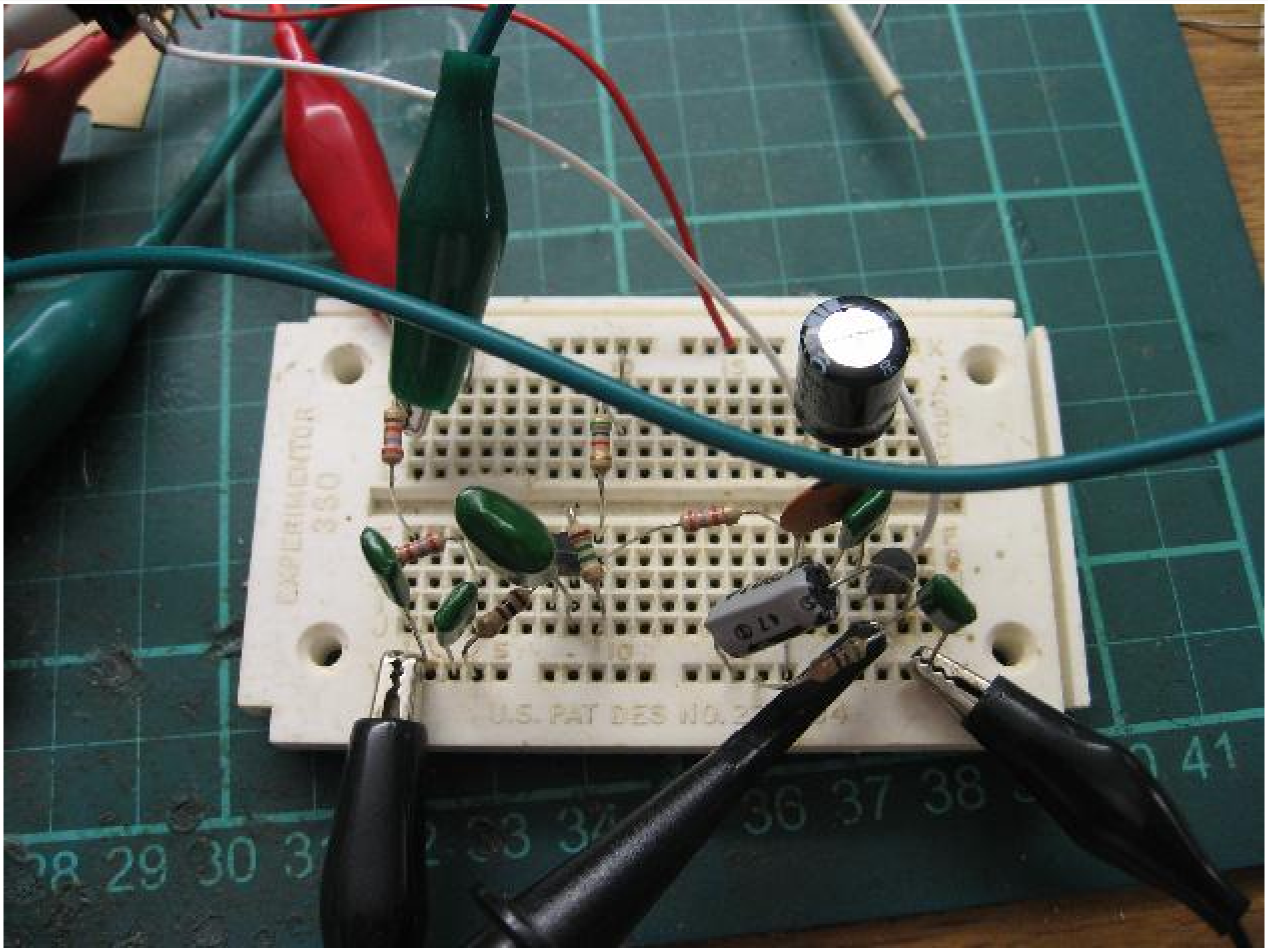
Receiver

With a good test signal now available, I started on the RX side. I imagine the circuit was meant to be super-regenerative, but it wouldn't super-regenerate for me. Perhaps I stripped out too much circuit when removing the TX bias and crystal, I've seen a base-quenched circuit before, but try as I might it wouldn't super-regenerate for me. Instead I replaced the emitter circuit with my more familar RFC to quench RC and it sprang to life.



I was fortunate enough to have a variable inductor in stock from an old eBay win that would cover the roughly 1.56 uH I needed to resonate with 22 pF I picked. I carefully dismantled the inductor (5 pin base, only a single untapped ~ 1.4-1.7 uH winding) and wound a two turn link onto its spare pins for the antenna connection.

With a small AF transformer in the collector feeding a sensitive telephone receiver, or a piezo earpiece across a 10K collector resistor I got audio of a similar amplitude to that of my single transistor transceiver. This is readable, but not very compatible with a noisy environment. To improve the circuit I built a two stage amplifier with some filtering that it capable of driving 32 Ohm headphones. The circuit is a simple two pole passive low-pass quench filter feeding a common emitter amplifier, followed by a Sallen-Key low-pass filter implemented as a emitter follower which can drive headphones directly to a reasonable volume.



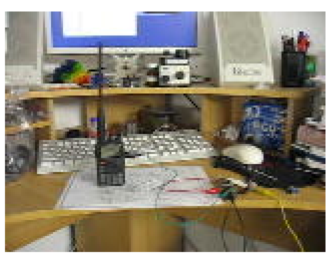
Notes

This is as far as I've gotten with the general idea so far, but I will likely be building a complete transceiver with similar circuits soon. I have lots of 27.195 MHz crystals, so there is a certain desire to use that frequency, but digging through the junkbox I also have lots of 21.330 MHz (15 metres) crystals too which might make it a more HAM compatible project.

I think a noise squelch would be a nice addition to the deluxe version of the transceiver. I have a prototype circuit floating around on a solderless breadboard which could be easily integrated, (unfortunately it is 4 transistors, which is nearly as many as the whole transceiver will be).

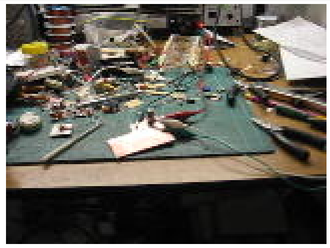
Videos

Here is a video of the prototype TX broadcasting some audio to the lashed-up RX.



Audio Test
(6.118 Mbytes)

And a video demonstrating the "AGC effect" of the super-regenerative detector. Note how the recovered audio amplitude doesn't change much as I give the receiver more signal, but the SNR improves enormously as my finger approaches the antenna input pad.



AGC Demonstration
(1.027 Mbytes)

12 comments.

2008-10-11: Circuit Diagrams for the AM Walkie-Talkie Experiments
I finally get around to writing up the circuit diagrams from this old experiment.

Alan's Lab

me and my geeky hobbies

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Antenna Experiments are Great Teaching Aids

2008-08-20

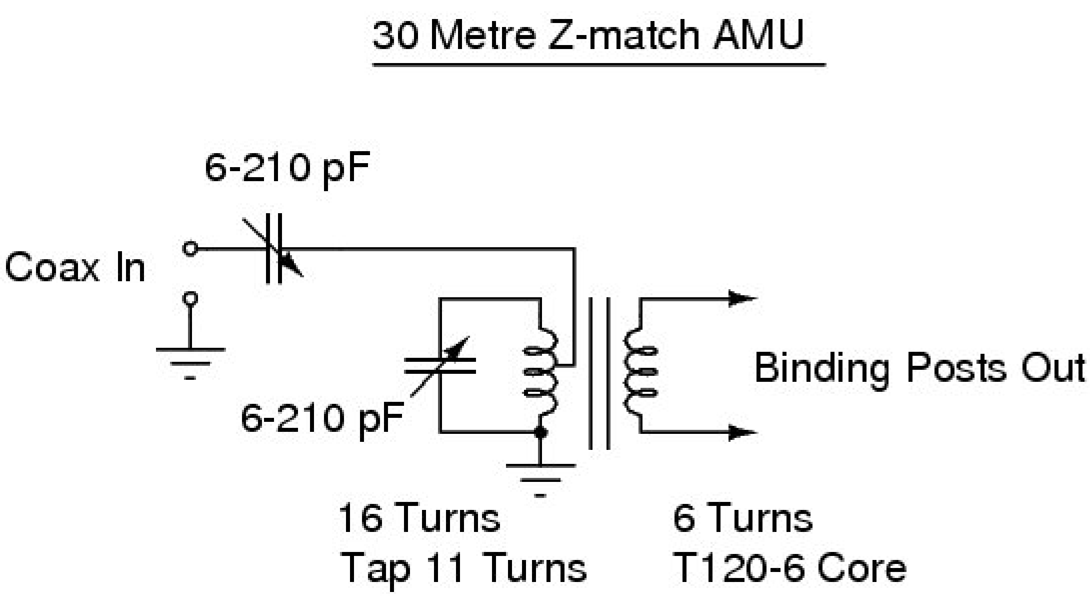
With the QRSS beacon now working pretty well it is down to getting the antenna system in better order. My limited space gives me little chance of a full-size dipole or vertical, so loaded compact antennas have been the mainstay of my station.

The Loaded Dipole

The 30 meter compact dipole is only about 5 metres long. It is currently erected sloping from the guttering to the balcony railing. Each arm has a 2 metre radiator then a ~27 uH loading coil wound on a piece of PVC pipe using 1.8 mm magnet wire, followed by a roughly 1/2 metre capacitive loading element which is rolled up at the ends to roughly tune the antenna. Fine tuning is achieved using the matching unit at the feed point.

The Matching Unit

The matching unit is a conventional Z-match topology.



The coil is 16 turns on a T120-6 core. The load winding is 6 turns over the main resonated winding. The coax centre feeds into the resonated winding via a 6-210 pF polyvaricon (both gangs together in parallel) at a tap 5 turns down from the "hot" side. The cold side is returned to the coax braid. Another polyvaricon is used to resonate the main winding, also using both gangs paralleled.

Achieving a match is an iterative process, but quickly finds very good return losses. I typically just hang the impedance bridge off the feed point while tuning up. No explicit balun is implemented, but current balance in the dipole appears pretty good (based on fluorescent tube experiments - see below) - that said no attempt to measure braid current has been made but it doesn't seem significant.

The Vertical

As detailed previously the 3 metre aluminium radiator used for the 80 metre beacon is matched simply with a polyvaricon (120 pF gang only) varying its effective capacitance as seen by the 7.8 uH loading inductor. The inductor is wound on a piece of ~1" OD PVC conduit.

Once the capacitance of the whip was tuned out it appeared as almost exactly 50 ohms resistive. This took me by surprise, I expected a much lower value. At the time I blamed excessive ground losses, but even then that didn't completely make sense as on 80 metres the loss wasn't anywhere near that bad and the increase in radiation resistance with the higher frequency couldn't explain the high feed point impedance either. It worked, so I choose to ignore the odd result... Big mistake, science 101; when your results and model disagree check both!

Antenna Interaction

While initial QRSS transmitting experiments were carried out on the dipole (the vertical matching not yet attempted), all the recent transmissions have used the vertical. The signal seems better in practice, but I was curious how much the two antennas interacted, especially after the odd feed point impedance measurements of the vertical. When I switched over to using the vertical I simply disconnected the feed line to the dipole and plugged it into the vertical in close proximity. With the Z-match still tuned-up at the feed point all seemed fine, but I got a very good lesson in electromagnetics when I checked the current distribution using a fluorescent lighting tube!

Field Around Dipole Loading Coil
(5.918 Mbytes)

With the vertical energised with only 1.5 Watts from the beacon TX I could easily light the tube in proximity to both dipole antenna loading coils. Clearly the antenna was parasitically absorbing a lot of the near-field of the vertical, no doubt re-radiating it and distorting the pattern of the vertical.

Field Around the Other Loading Coil
(3.862 Mbytes)

Experiments have just begun into the nature of the interaction, but detuning the Z-match or disconnecting it reduced the antenna current to negligible levels. Unfortunately this causes the feed point resistance of the vertical at resonance to drop enormously and offer a very poor match to the feed line. Remote signal levels seen in Grabbers are inconclusive, signals seemed to improve immediately after the change, but have since dropped off and now appear much worse! Only careful experiments with switching the resonance on and off could really tell for sure if the pattern produced by the interacting antennas is "better" for some destinations or not. Experiments such as this are complicated to implement because of the interaction itself and how much it changes the feed point impedance of both antennas. For an "apples to apples" comparison the antenna configuration in use must match the TX properly, accept all its power and not change the power the TX can generate (i.e. offer the same load).

Another complication was noted, the change in return loss of the vertical caused the beacon TX internal temperature to change, resulting in a visible drift of the beacon frequency by several Hz. A similar effect was noted when a freak sleet storm detuned the antenna enormously by covering it in icy slush. This is a form of drift I didn't predict after having gone to quite a length to minimise direct load pulling. I did have second thoughts during assembly about putting the amplifier inside the same box because of its heat generation, I had hoped it would just help keep the beacon above room temperature - which in fact it does quite well - but variations in dissipation with load condition is now something else to consider. Nature is often a very inconsiderate teacher, but a completely consistent one at least. No doubt people in the space program and other mission critical engineering applications have similar battles with what is totally obvious *after* it happens.

Fixing the Vertical

With the dipole no longer significantly interacting with the vertical I measured the input resistance of the vertical + loading coil at resonance as almost exactly 16 Ohms. An L-network was designed to match this to the 50 Ohm transmission line. The series inductance of the L network is small enough (370 nH) to absorb into the existing 7.8 uH loading inductance, leaving just the 458 pF shunt capacitance to be added. A 470 pF silver mica transmitting cap was soldered across the feed point allowing an excellent return loss from 50 Ohms to be achieved.

The feed point resistance once resonated on 80 metres was 22 ohms (must recheck this value my technique and instrumentation has improved since then). With a 500 milliohm radiation resistance on 80 metres this puts the antenna efficiency at about 2.3 % or about 16 dB down on a lossless 1/4 wave vertical. A similar calculation for 30 metres where the radiation resistance is about 4 ohms gives 25% efficiency or 6 dB down. 6 dB is one S-point - the loss is fairly trivial on 30 and not a massive deal on 80 either despite what might be called woeful efficiency.

How valid is this loss figure? If we take the 16 - 4 = 12 Ohm loss resistance for 30 metres and assume half of it is from the inductor finite Q then the Q figure that would give 6 Ohms loss is only 83 (XL ~= +j500). One hopes the inductor Q is better than this... Lets assume the inductor Q is at least 150 which seems reasonable, this is a

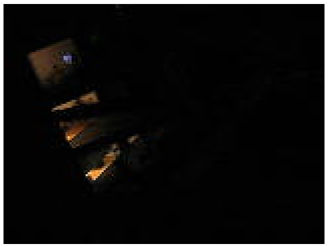
ground loss seem reasonable? The balcony railing is Stainless Steel which means it has a higher resistivity than Copper, but also a deeper skin depth as a result. Physically it isn't large enough to be a "good" ground-plane, so 10 Ohms does sound fairly reasonable IMO.

For 80 metres where the XL is 1.4 kilo-ohms we have about 10 ohms more apparent loss. An inductor Q of about 117 gives 12 ohms of loss to add to the 10 ohms of estimated ground loss (likely not the same on 80). The geometry and construction of the 80 metre loading inductor could easily see its Q in this region. Measurement of the actual inductor Qs at the frequency of operation would be instructive to get a better estimate of ground loss, but it is obvious that the antenna efficiency is likely dominated by the ground losses on 30 metres and even the best efforts to improve loading coil Q on 80 won't improve the overall system efficiency all that much.

Other Notes

Because these are narrow-band devices and matching techniques, the return-loss seen on your instruments will rapidly tell you if you have a harmonic energy problem. A good return loss peak (or null if you prefer) will be almost impossible to achieve unless the transmitter is fairly spectrally pure.

My fluorescent tube ionises more easily than an NE-2 bulb - this was surprising. However its ionisation hysteresis seems larger. This is probably predictable as it is filled with an Argon/Mercury mixture rather than Neon and the pressure is likely quite different, but an interesting observation none the less.



Ionisation Threshold Effect
(5.958 Mbytes)

The impedance of the 3 metre vertical is much lower on 30 metres than on 80, hence the Q is smaller and tuning up is easier and less touchy. Also the RF voltage produced at the same power level is smaller so Polyvaricons are quite suitable in the matching network. This also means my usual method of using an NE-2 bulb hanging off the mast clamp to tune for maximum output doesn't work. :(One of the big advantages of QRP is that you don't need insanely good components to withstand the voltages and currents associated with QRO operation, and you can't really burn yourself even from high-Z points.

Antennas aren't magic. I know that is stating the obvious, but like most Hams I think I am a little in awe of how a piece of metal the right size and shape can transduce electromagnetic energy with space. The laws of physics still apply and even your basic AC circuit theory is usable in the antenna domain. Radiation can make it seem like it is different, but if you model radiation much the same as loss (an extra resistance) it all works and makes sense. Antennas can be extremely confusing at times, and it is all too easy to omit the major radiator from your model! If experience has taught me anything about antennas (or RF in general) it is that you have to measure everything you can, confirm your assumptions and test your model. The more I work with antennas the more I am driven to build test equipment, especially impedance bridges, RF ammeters and (calibrated) field strength meters. To me this is what Ham Radio is all about, a technical hobby of life-long learning about the electromagnetic force of nature.

Leave a comment on this article.

Attachments

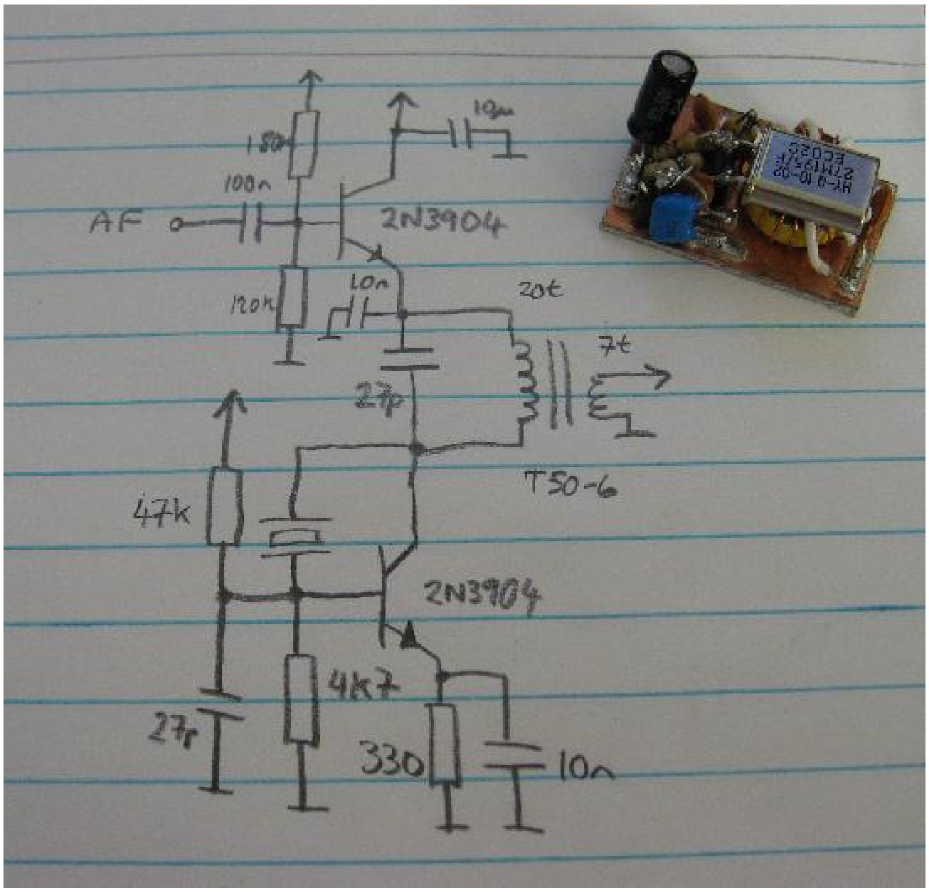
title	type	size
Z-Match Circuit Source	application/postscript	10.743 kbytes

Circuit Diagrams for the AM Walkie-Talkie Experiments

2008-10-11

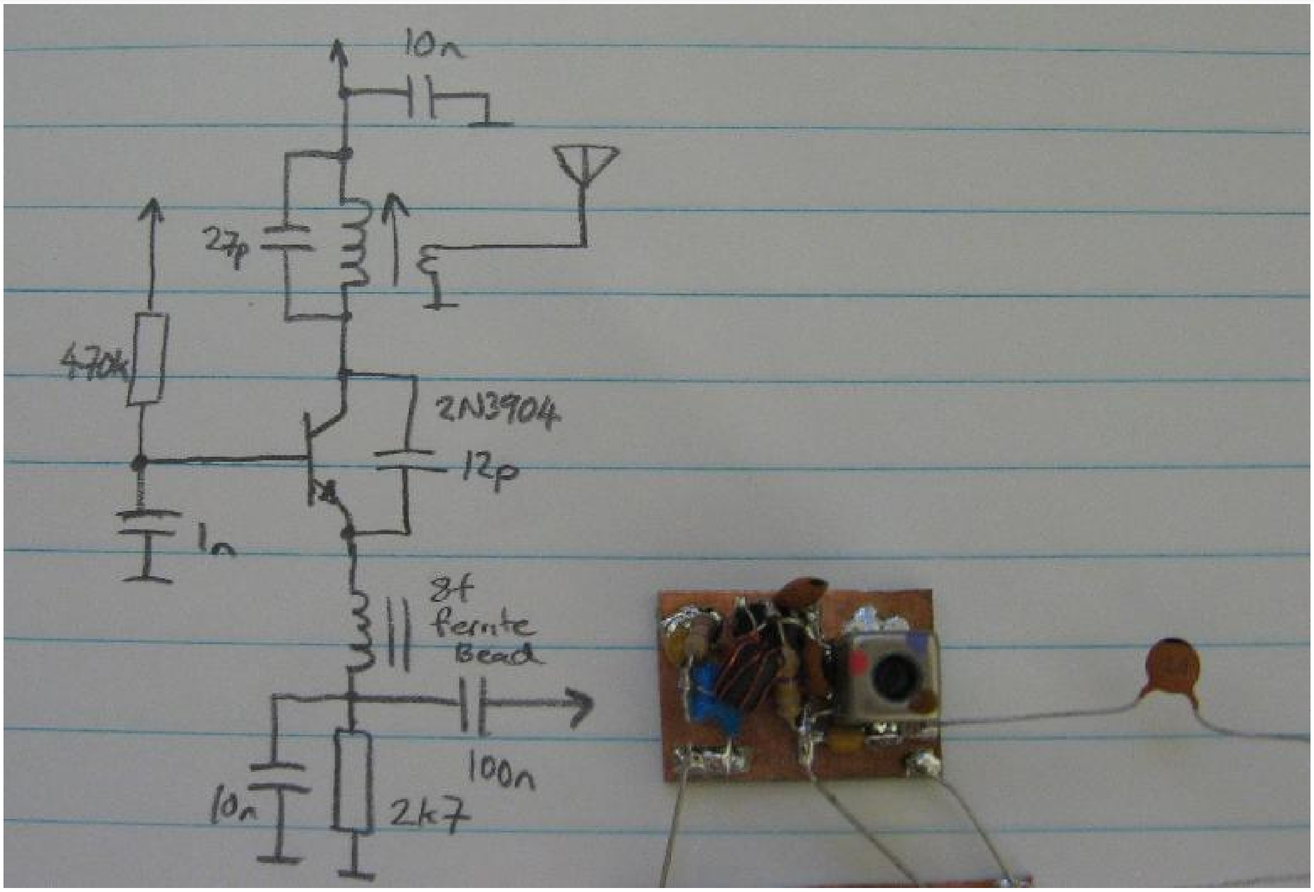
A lot of people have asked for the circuit diagrams for this experiment, so here they are...

TX

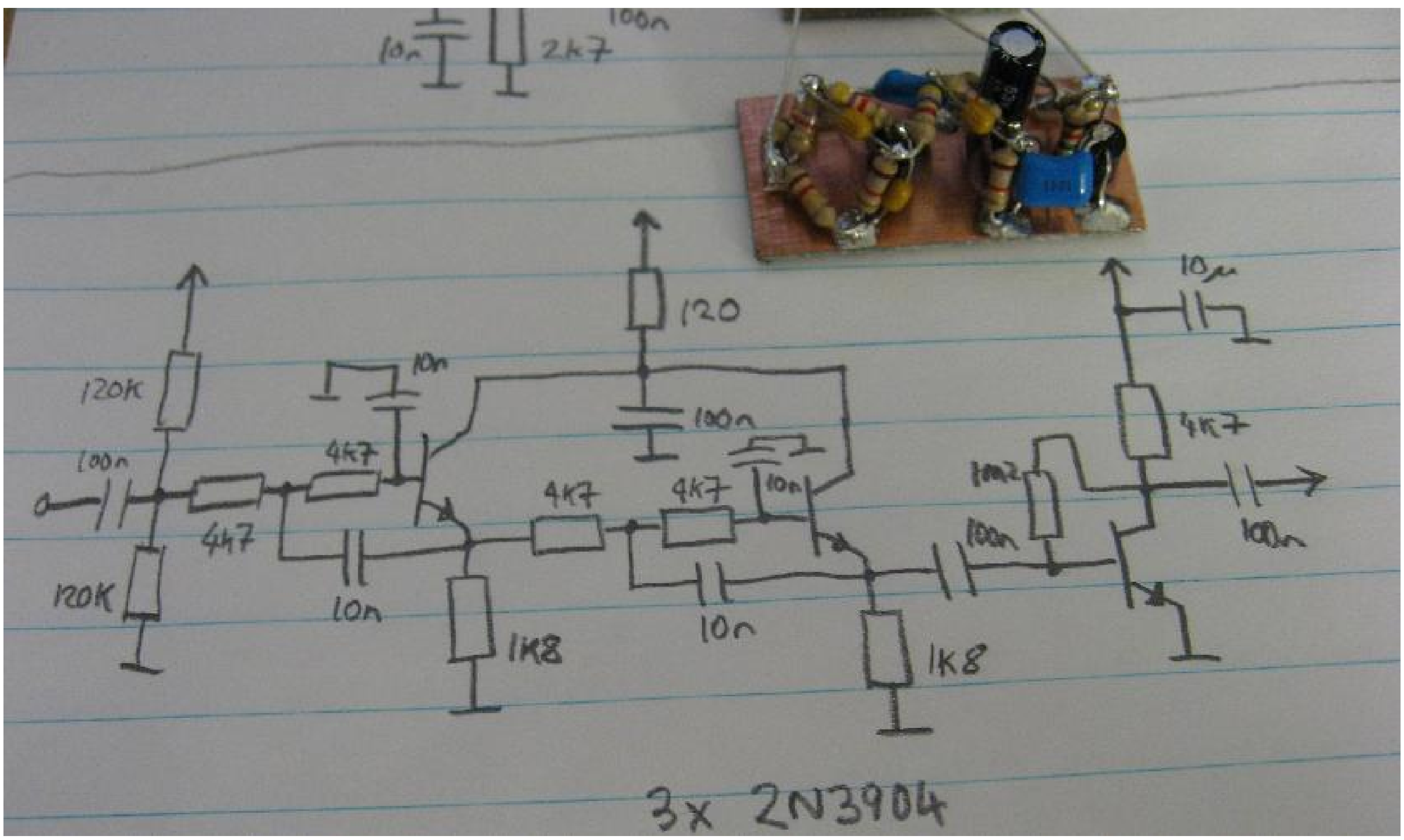


The 7 turn link output is resonated with 47 pF to get reasonable power out, but it is still quite a feeble transmitter.

RX



The coil for the detector is described in the [original article]



Higher Q filters might be better, but these work and are very simple, using the same R and C values - which might be considered a feature.

Comments

To make a full transceiver you'll need a microphone amplifier and probably a loudspeaker amplifier although the output of the AF filter board drives a xtal earpiece just fine and small low-impedance headphones to some degree.

You'll probably want more output TX power, the design delivers about 2 mW PEP! You might consider collector modulating another RF stage driven by the xtal oscillator instead of the oscillator itself.

Design supply voltage is 9 volts.

The xtal case is grounded in the TX. Ungrounded the amplitude modulation linearity is effected - I am not completely sure why.

4 comments.

Parent article: AM Walkie-Talkie Experiments.

End-Fed Half-Wave Antenna & Tuner

2007-03-11

For the on-going 2007 ARNSW Homebrew Group Challenge work I needed a simple 80 metre antenna. As a home-unit resident the size of a full half-wave is pretty impractical, but I decided to try it so I had a base-line to compare future shortened verticals to.

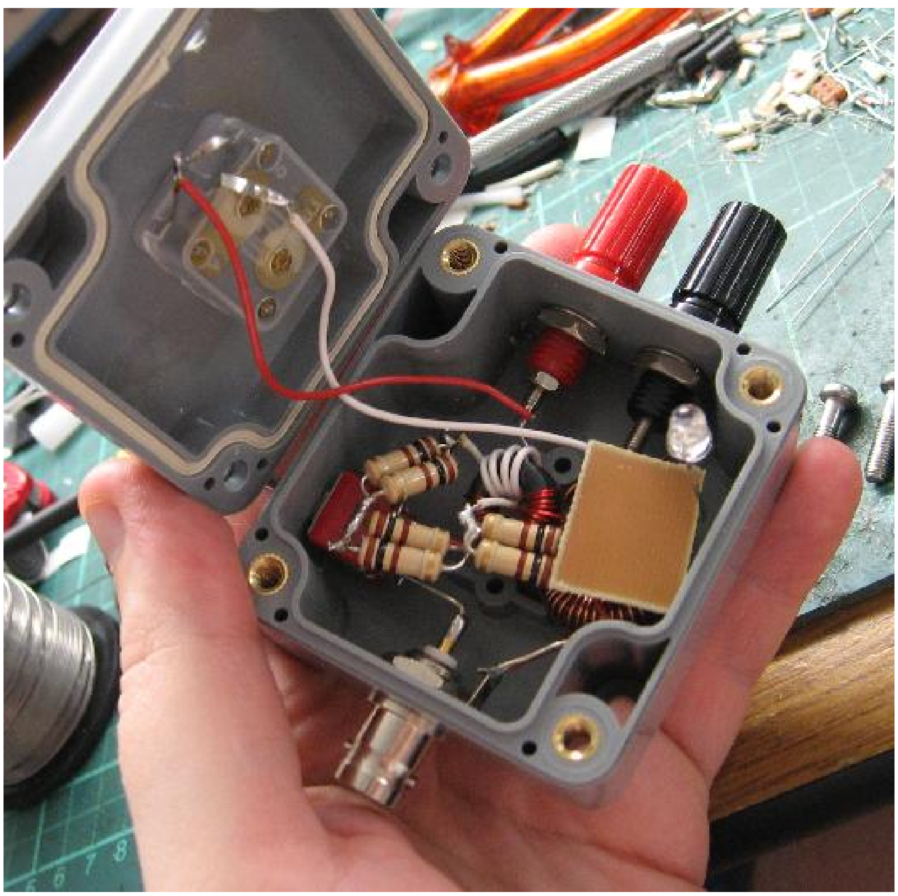
While centre-fed would be the simplest to get going and probably the easiest to install in a semi-permanent manner, I went with end-feeding. I would like to have the option of using the antenna portable, where a transmission line is just something else to carry and end-feeding is probably the easiest to set-up.

I read everything I could on the subject, the ARRL antenna book is good, but I found Steve Yates AA5TB's website especially useful. Steve explains the physics of the counterpoise well, and gave me confidence that it would indeed work as I had planned without stray-RF problems.

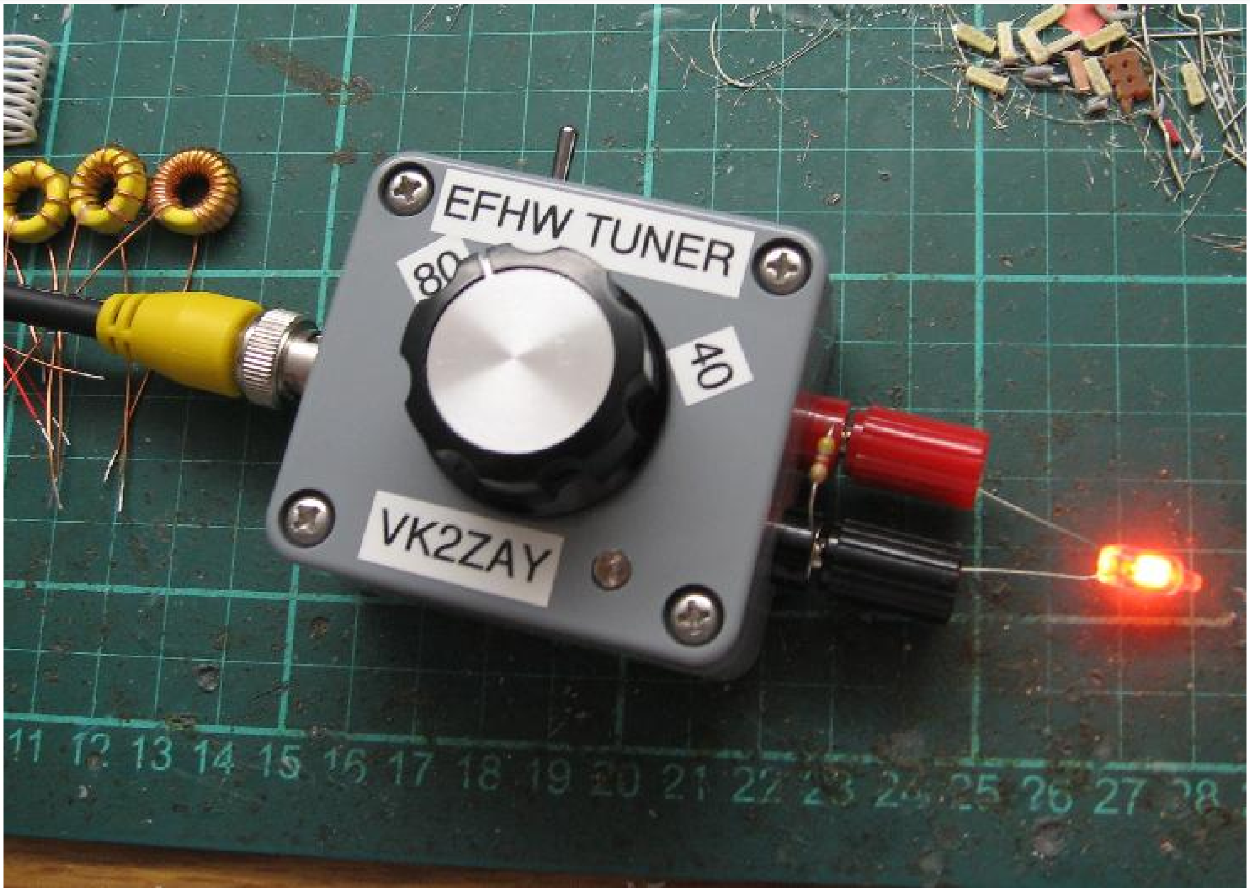
The Tuner

A matching box was constructed, containing both a matching circuit and a resistive 50 Ohm VSWR bridge that borrows heavily from Dan Tayloe N7VE (et al). The matching inductor value was picked to resonate the available variable capacitor gang just below 80 metres at maximum capacitance. The Hi-Z side floats to make it more versatile, a simple clip lead can be used to return the counterpoise side to the coax braid, if so desired.

The final device tunes a resistive load of 3-7 kilo-Ohms from 3.2 MHz to 12.6 MHz. 40 metres is covered (and 30 metres too, but I lack a transceiver for it currently), it is unfortunate that 20 metres could not be covered as well, without switching out some of the windings. W0CH switches his inductor taps, but this also changes the impedance match too much for my taste (Note that you can compensate somewhat for a few kOhms of resistive mismatch and an undetermined amount of reactive mismatch with the tuning). His circuit is otherwise very similar to mine (and just about everyone else's who has an internal bridge).



The unit was built in a small plastic box, and it was quite a squeeze to fit the tuner and the bridge inside. The resulting unit is very small and should work fine in portable operations. The tuner can be seen running about 1 Watt CW from the challenge transmitter into a 4k7 dummy load and a neon bulb which is getting stinking hot!



This gross abuse of a Neon bulb shows the voltage step-up of the tuner and proves it can feed a high impedance load fairly efficiently.

The Antenna

The radiator itself is simply a half-wave long piece of wire. I used an unzipped length of "zip cord", a full free-space half wave length (about 41.6 metres) which makes the antenna a bit reactive, but this is easily tuned out. Managing the wire while it was measured and unzipped was actually one of the more challenging parts of the project, but with the help of the XYL and the parents it took only 20 minutes or so. Black plastic egg insulators from the WICEN stand at Wyong were strung on the wire, two fixed at each end and two floating to allow various geometries for deployment. Banana plugs were added to each free end of the wire, so either might be used as a feed point.

Testing

After some trial and error it was found possible to just fit the antenna's enormous length on my property. The centre was strung up at my 3rd story bedroom window and the ends sloped down to the extreme boundaries, one being the car park railing at the edge of a cliff, the other being the adjoining property's fence. The car park end was the most practical to feed from, so I took some gel-cells, a few radios and a fold-up chair down to the cliff edge and set-up there.

The antenna works much better than any I've used before. The inverted-V configuration may have something to do with this. I used the railing around the car park as a counterpoise, but it was possible to run using just the radio and its coax as a counterpoise too, by clipping the counterpoise connector to the coax socket outer with an alligator clip lead. It was very easy to tune in either way, on both 80 and 40 metres. The ARNSW morse practice beacon was full-scale on my VR-500, were normally is is barely S1 on my north-south horizontal 40 metre dipole. With a homebrew 80 metre transceiver I could hear lots of DX and local QSOs, and I listened to the WIA broadcast using my 80 metre VXO receiver for the first time at a good signal level. As the sun went down the mosquitoes got too bad to stand any longer, so packed up and went back indoors.

I had to take down the antenna, it is simply too big to leave up all the time, if I want to keep the neighbours on side anyway. The car park end is also a bit of pedestrian hazard, so this antenna will only be going up for special occasions. The experiment was otherwise a complete success, and I am very impressed with the antennas performance. I also now have good figures to shoot for with a shortened vertical.

5 comments.

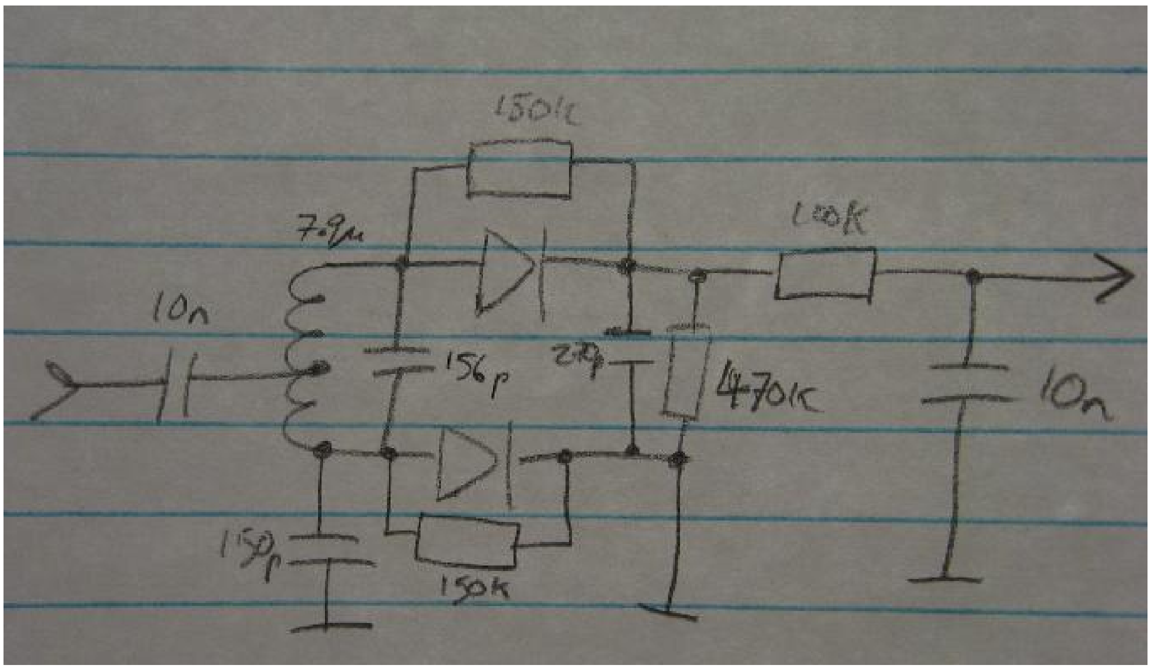
FM Detection Experiments

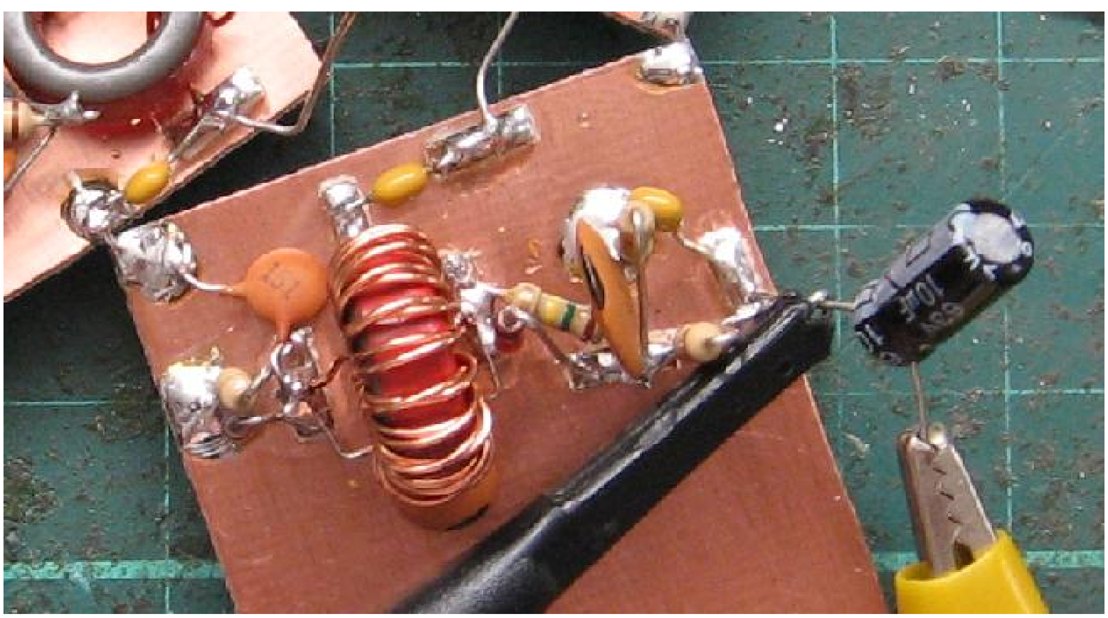
2007-05-19

Some time ago I found some 4.5 MHz filters on eBay designed for TV audio IF stages. When they arrived I just put them into the junkbox and forgot about them until now. This weekend I was digging around for a filter for another experiment and found these. This triggered the usual "What can I build with this?" thoughts, and eventually lead to these experiments - I decided to build an FM detector IF strip.

Foster-Seeley Discriminator

Working backwards from the detector, I first constructed a Foster-Seeley Discriminator on the solderless breadboard and got it working with a centre frequency of near 4.5 MHz. This circuit was then soldered into its final implementation and tested. The resonator is a 7.9 uH inductor which is bifilar wound on a T50-2 core, resonated with 156 pF. I eventually replaced one of the fixed capacitors with a trimmer to allow precise centring of the detector slope. The diodes are unmatched 1N4148 garden variety rectifiers.



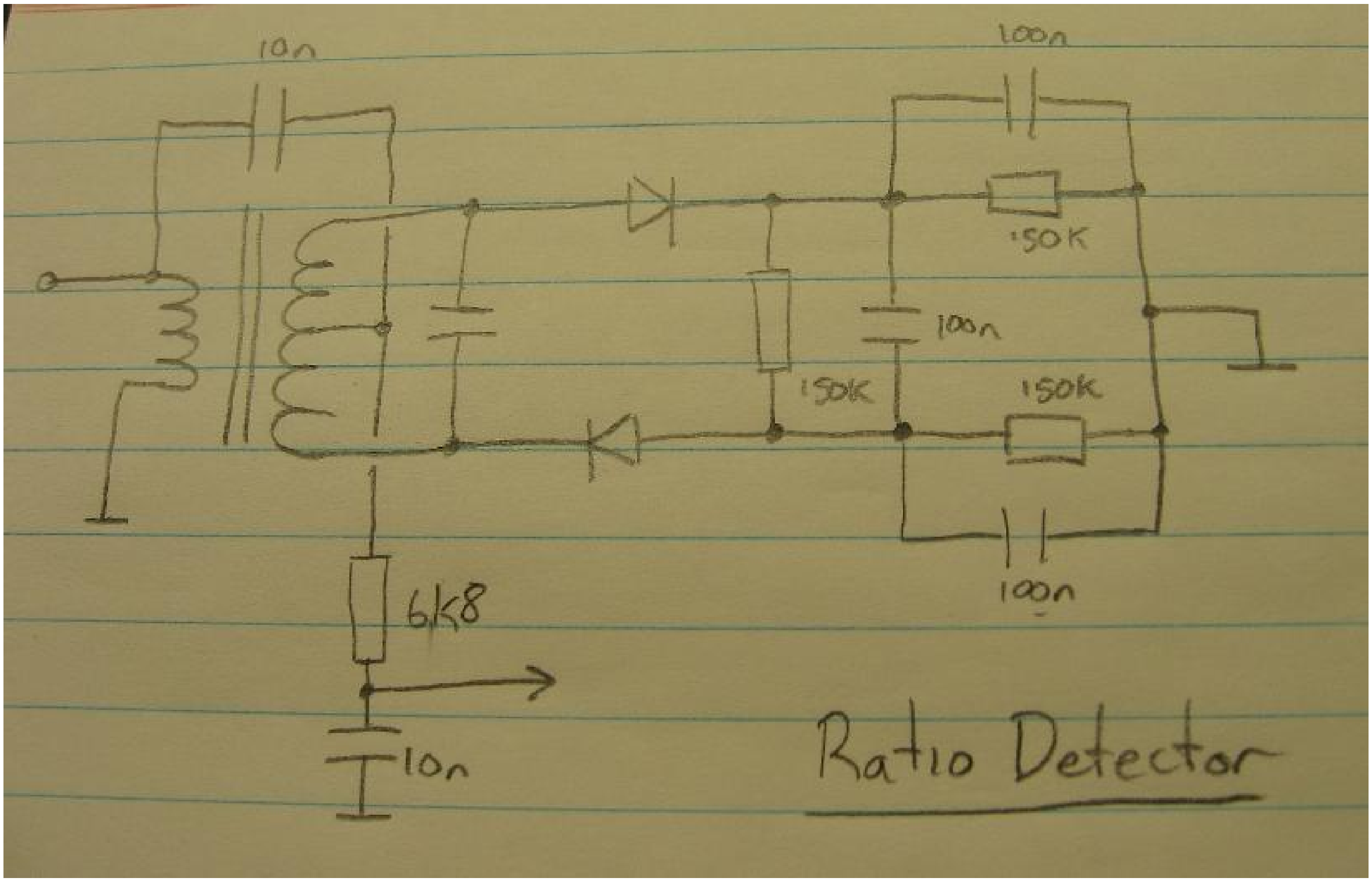


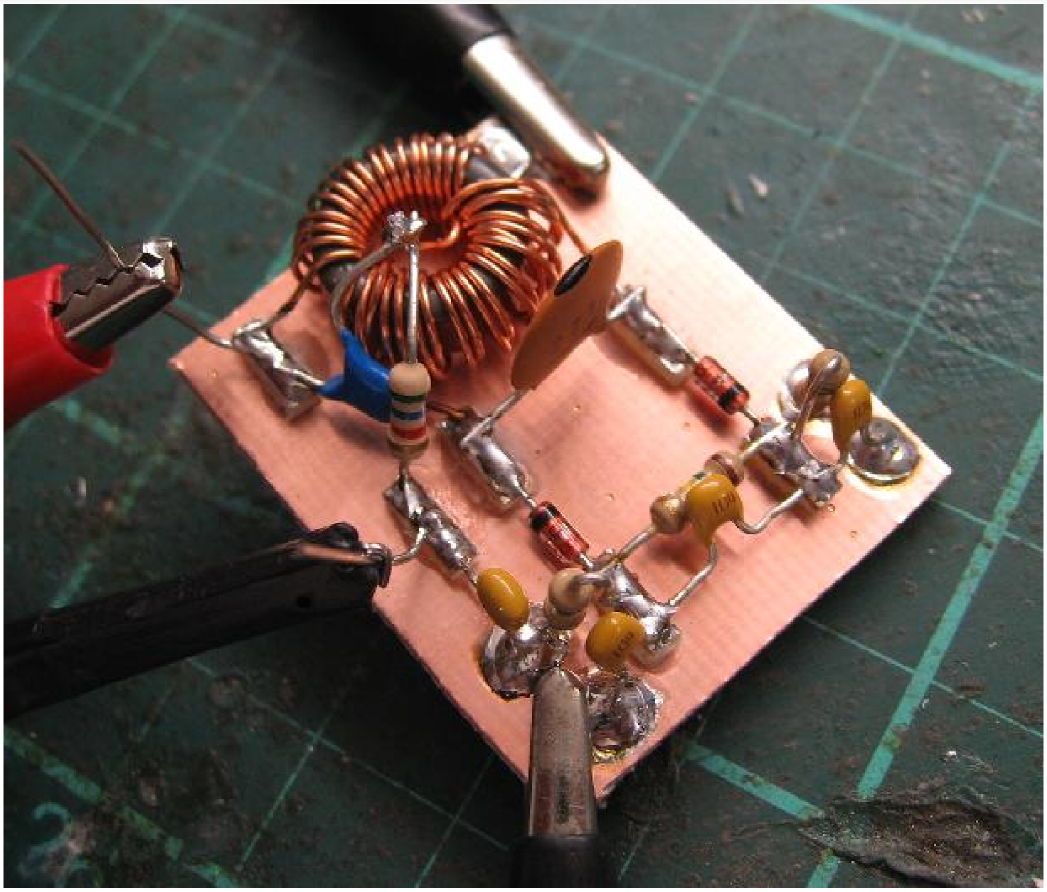
The big problem with this detector is its input amplitude dependence, meaning ideally I need to limit the IF before application. For now, I decided to ignore this and enjoy the fact it offers a much larger output signal than a Ratio Detector which is essentially amplitude

Ratio Detector

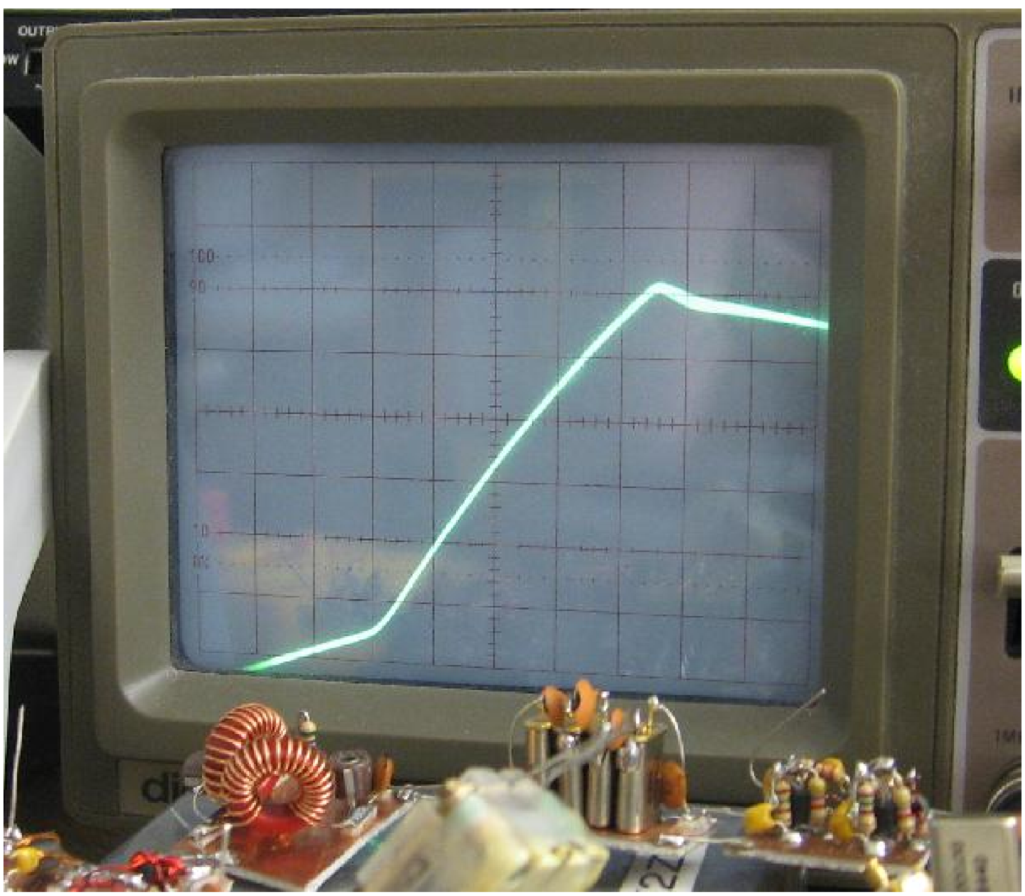
I tried building a traditional Ratio Detector, but I had a lot of problems getting it to work. I am unsure exactly how the third winding is meant to be coupled to the other two windings. It is also a lot more touchy to tune up, you have to resonate both the primary and secondary, the diode matching seems pretty critical too, the DC swing across the slope wasn't very symmetric in my experiments, but that might have something to do with my lack of understanding of how to couple and phase the third winding. **Any feedback on how to get this working would be greatly appreciated!**

With the solderless breadboard and a bit of evil empiricalism, I eventually made something that seems to be a Ratio Detector, in fact it works quite well and seems to have good (but not perfect) AM rejection. The topology is similar, but not quite a classic ratio detector:





It does not exhibit the classic "S" shaped discriminator curve, rather a slope through resonance without a noticeable peak at the bottom (but a small one at the top):

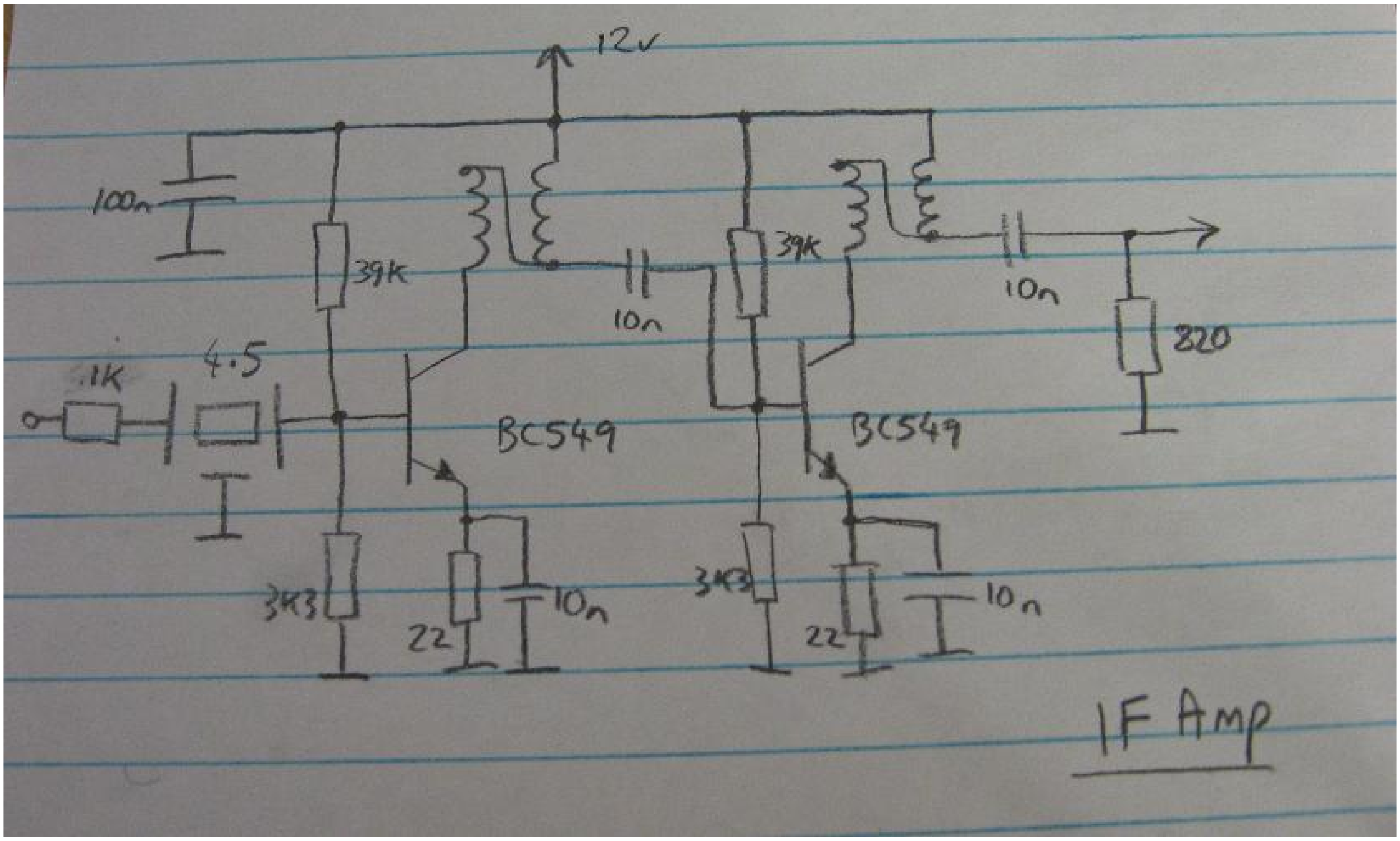


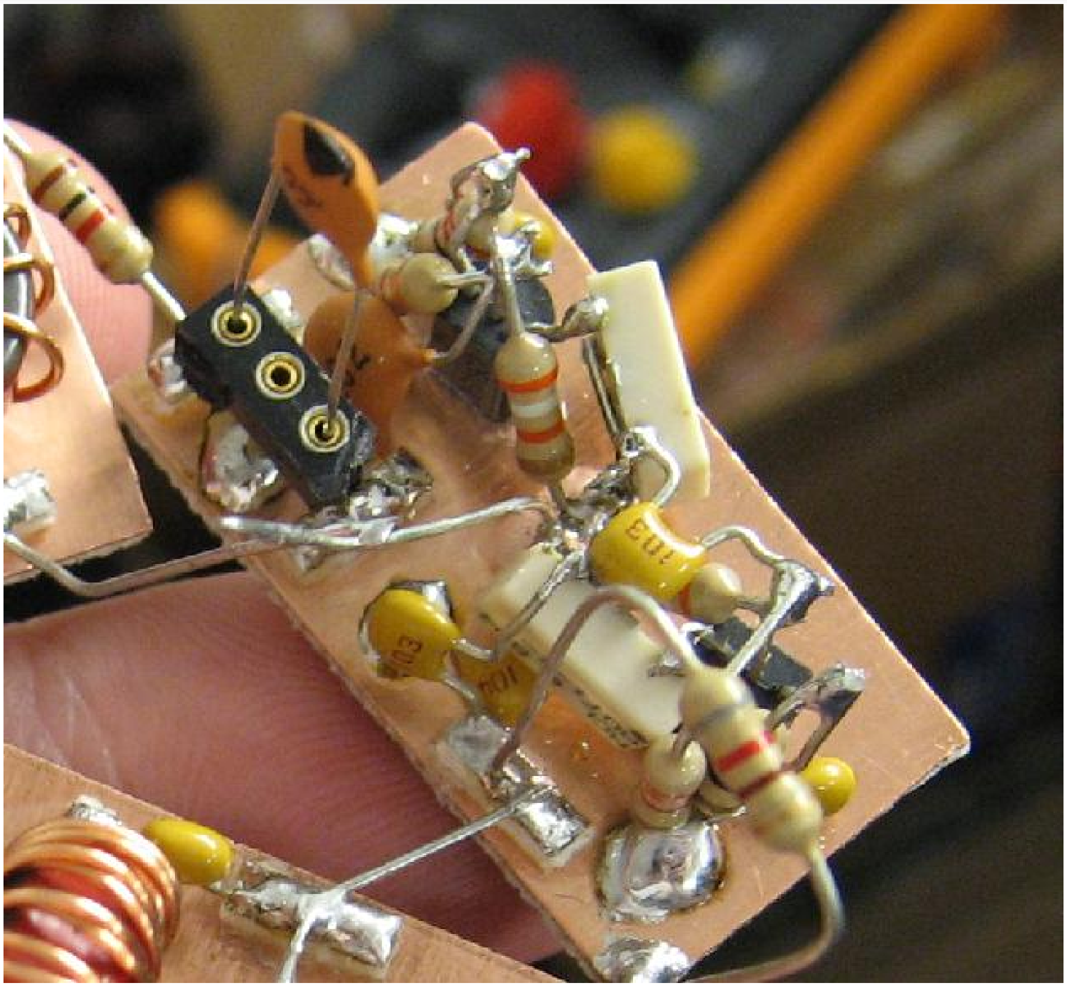
As I do not completely understand this circuit I decided to leave it aside for the moment. It does work and is elegantly symmetric and fairly easy to build, so I will come back to it. I believe it may be acting as a resonance bridge, and producing a DC signal proportional to

IF Amplifier

I proceeded with the Foster-Seeley Discriminator, now I had to build an IF amplifier that matched the output impedance of the filter. I had some trouble finding the specs on the filter, but it appears to be 1 kilo-Ohm in and out, and prefers a little capacitance on the output side for best ripple. A two-stage basic common emitter amplifier was constructed using BC549 devices and, for a change, ADT1-1 minicircuits transformers in the collectors. (Laziness, pure and simple, the ADT1-1 is an SMD device, rated from 150 kHz to beyond 400MHz, but I got a reel of them of eBay for about $40. You can use any old ferrite bifilar transformers giving a winding reactance of at least a kilo-Ohm or so, ferrite beads or FT23-43s will do, as would BN-x and FT50-43 or larger if you don't mind the size.)

With the filter in place this amplifier gives a transducer gain of about 38 dB at 4.5 MHz. The input impedance at the actual base of the transistors was measured at around 380 Ohms and somewhat capacitive, a little low for the filter, but not too bad. The output is "low", and with the collector transformers the inter-stage match is actually quite acceptable, but the final device will be driving the high-Z discriminator. I shunted the output with an 820 Ohm resistor to improve its stability. For now, the losses and noise figure issues of this IF hack will be ignored.



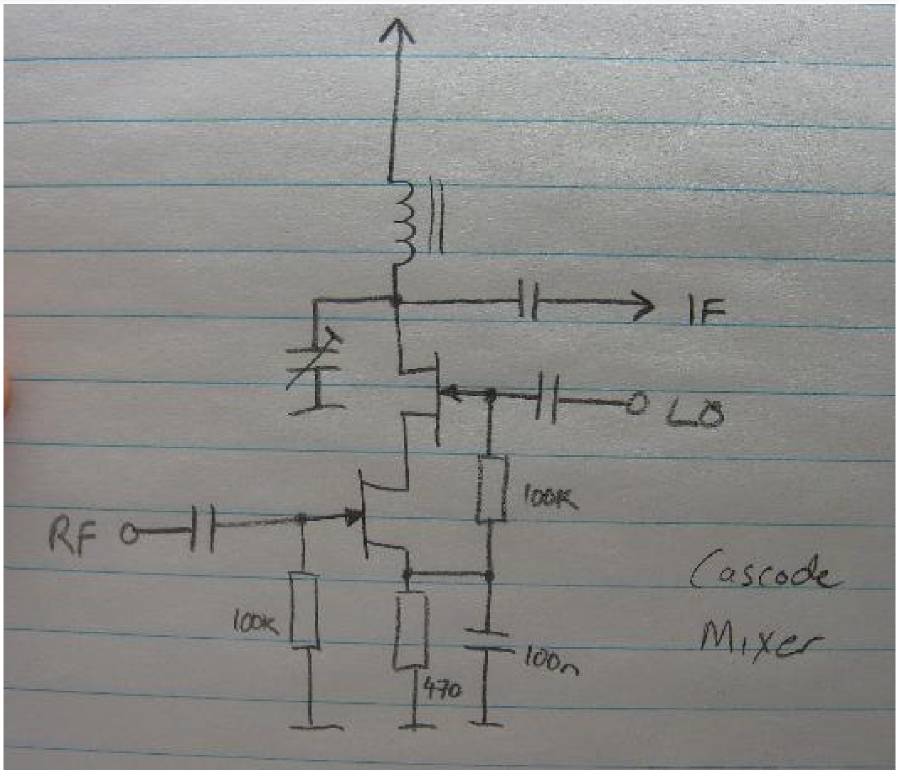


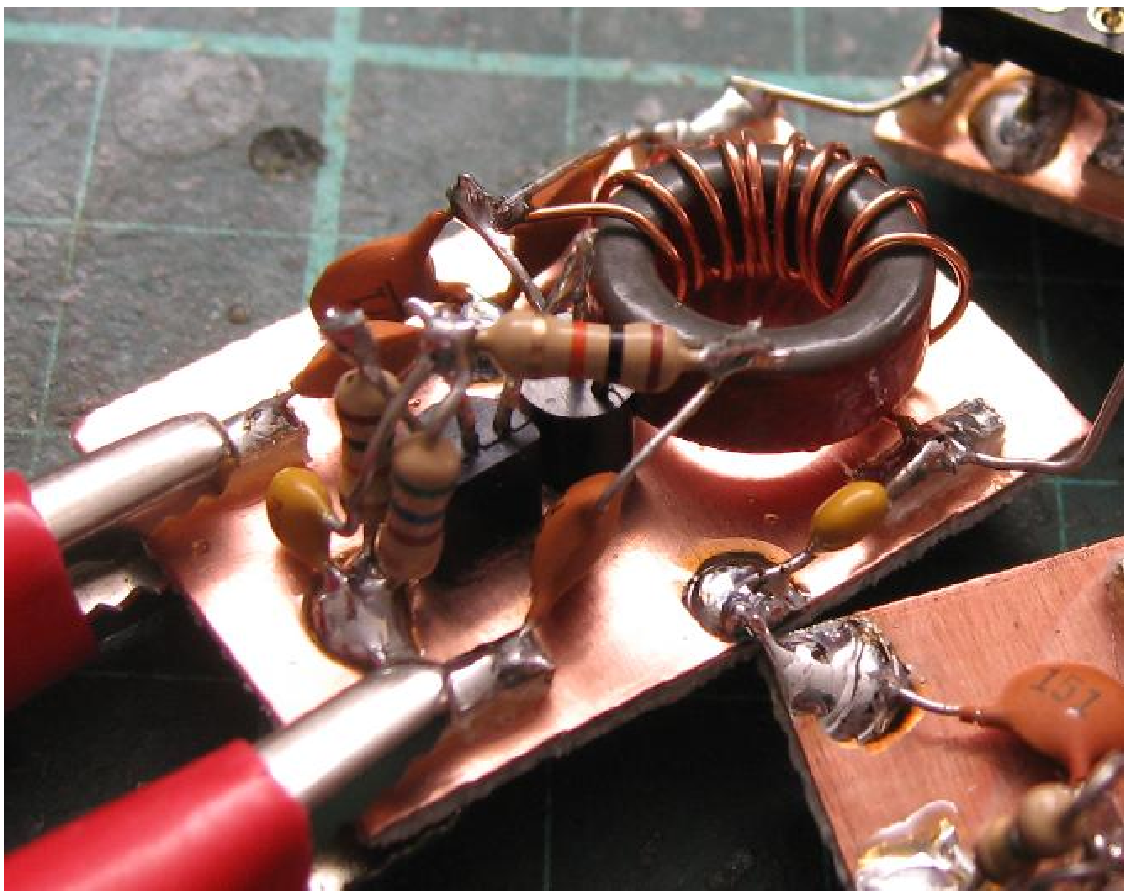
The assembled IF and detector modules were tested, and proved capable of detecting the 1 mW output of my signal generator across the bench using just my finger on the input-side of the filter as an antenna, and those Archer mini-amplified speakers as the AF stage. (The input impedance of the amplified speaker is actually far too low, and worsens the distortion of the detector a little. I've left space on the detector board for a higher-Z buffer at some point.)

Mixer

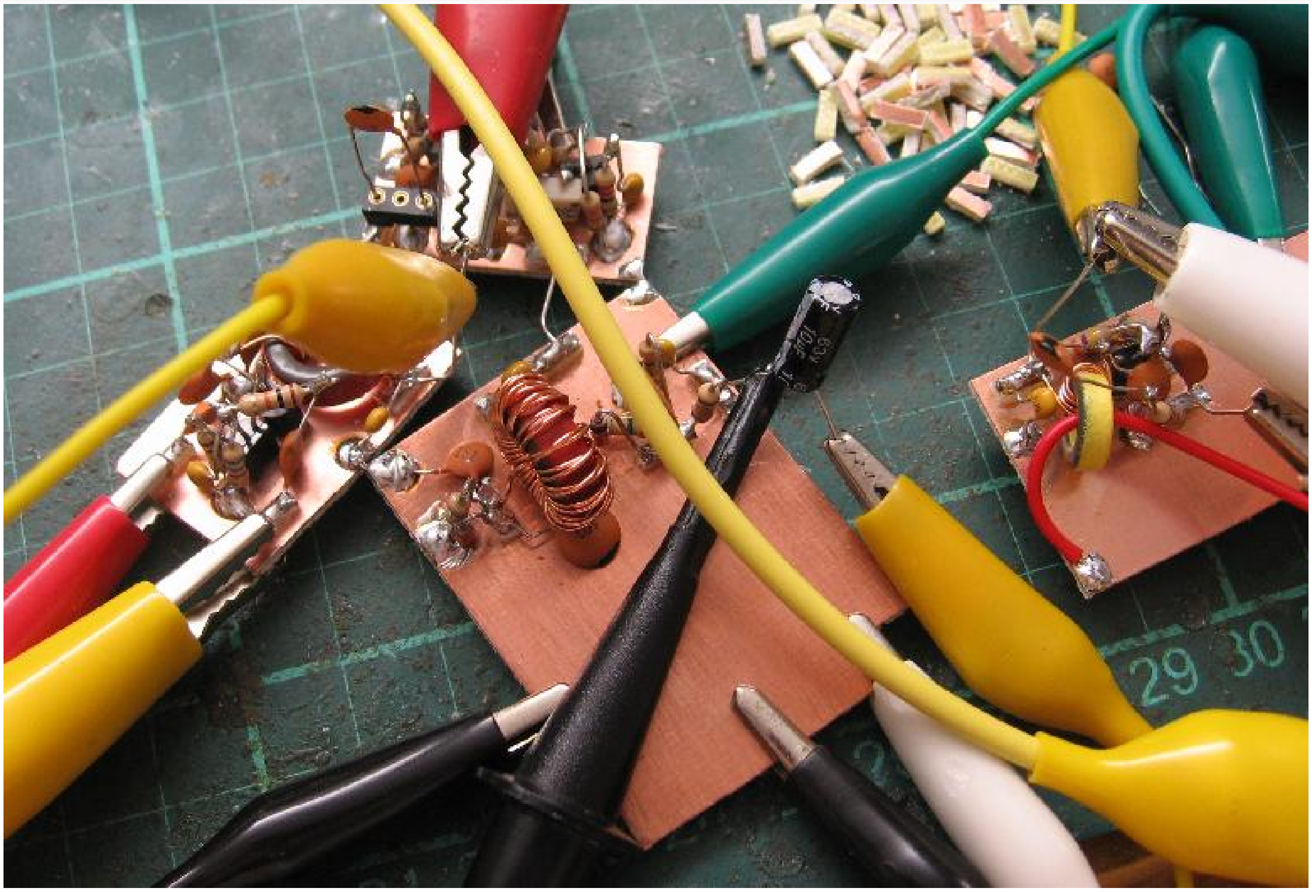
Now I needed a mixer to convert the RF down to the IF. I considered using my traditional diode mixers, even contemplating using a TUF-1 or SBL-1 rather than spending half an hour building a diode mixer from ferrite beads and wire. Instead I did something completely different and new for me, I constructed a cascode FET mixer with a pair of J310s. My dislike of the cascode mixer is well-known, but in this particular application it works wonderfully. It works to beyond 200 MHz and is extremely simple. I would have used the dual-gate FETs that John VK2ASU gave me, but I wanted to save them for a more critical application.

The drain circuit is a 4.5 MHz resonator to select out the IF and try to reject all the garbage that the cascode multiplication doesn't balance out like a gilbert cell will.



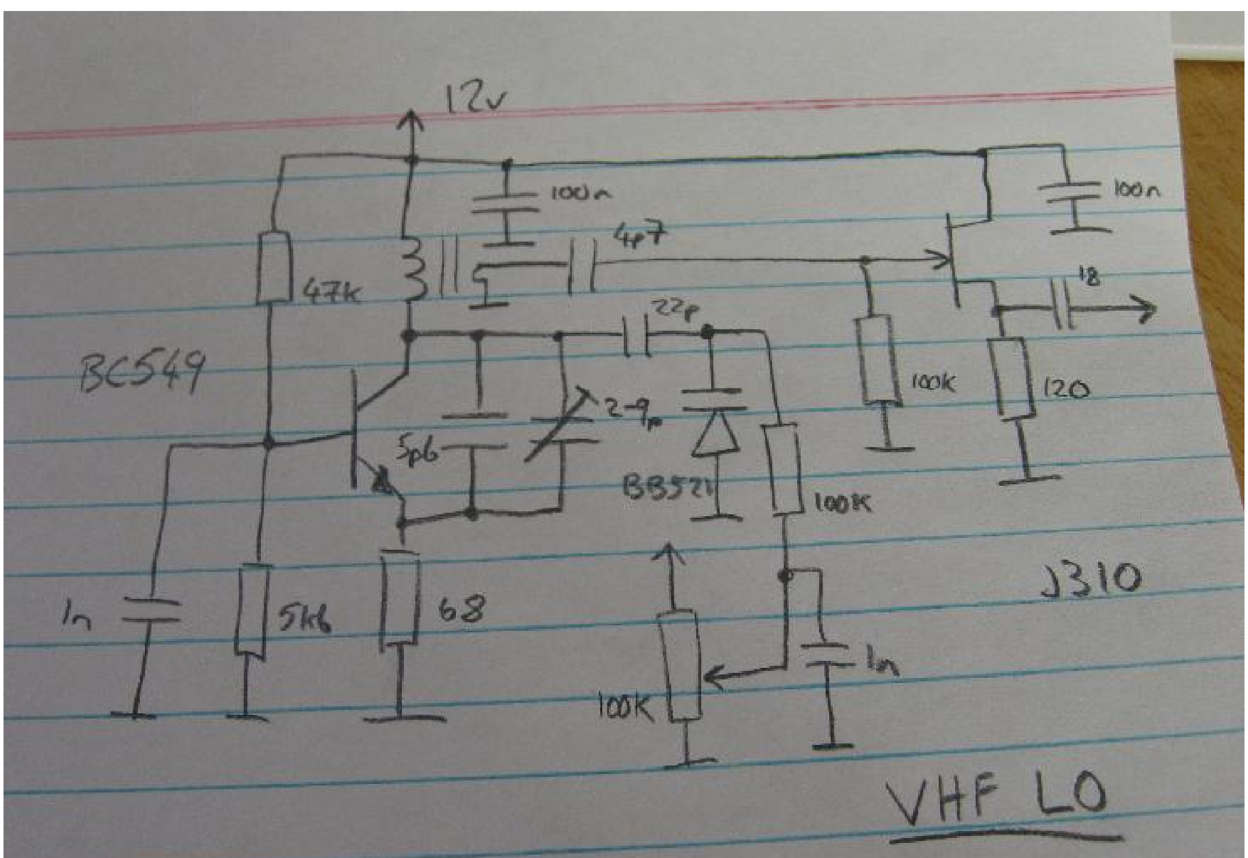


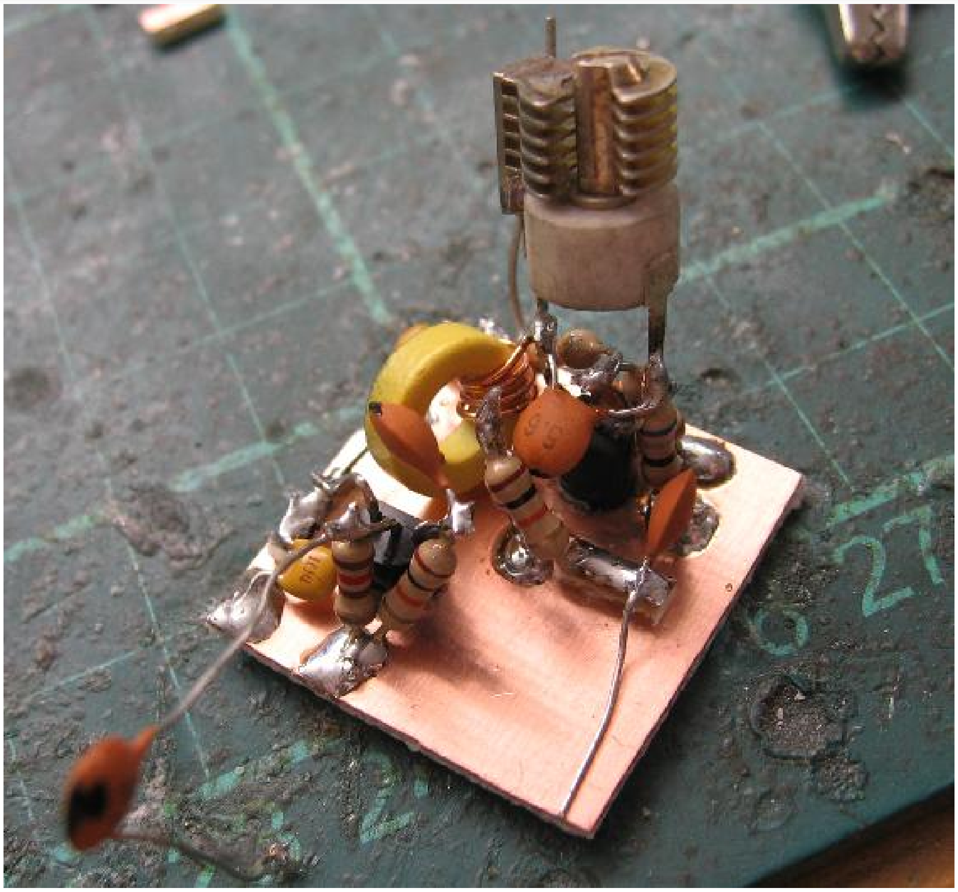
Just for a laugh, I connected a 3 meter (FM broadcast) band folded dipole to the bottom FET and my signal generator to the top one. To my complete surprise I could tune in FM broadcast stations, but the filter was too narrow to allow their full deviation through. Oh a whim, I pulled out the filter and replaced it with a 22 pF capacitor, amazingly this allowed me to receive FM stations with quite impressive clarity! This actually blew me away, the selectivity was quite acceptable with absolutely no filtering beyond the drain resonator and the discriminator resonator. It appears that a similar circuit could used for an FM broadcast receiver.



Local Oscillator

Thoughts of a VHF Autodyne Converter filled my head - but instead I built a varicap tuned common-base oscillator for the LO injection. This worked well and produced a quite acceptable FM broadcast receiver. (Curiously the floating LO port of the mixer was sensitive enough to weakly function with the leakage from the LO stage a few inches away, but I opted for direct connection.)





Discussion

Attempts to use this assembly to detect 2 metre narrow FM transmissions has been unsuccessful so far. The LO is not stable enough for this purpose (it is fine for wide-FM though), so I am considering building a pre-mix VFO based LO, probably with an LC VFO around 8-10 MHz and a high-side crystal oscillator module or multiplier chain. A VXO and multiplier chain might be a possibility, but a suitable crystal frequency I don't appear to have in the junk box.

The filter is also too wide for good selectivity of narrow-FM, but this is easily fixed, I can build a new filter using computer crystals and adjust the resonators to match. Using the current filter I have listened to TV channel audio signals, for this purpose it works very well and which indeed it was originally designed.

To complete it as a usable receiver it needs a front-end band-pass filter and LNA. A J310 common gate amplifier and series-tuned filter would be sufficient for experimental use, but a coupled parallel resonator filter would be a better idea for the final receiver. The IF is just high enough to give reasonable image rejection on 2 metres with just a BPF, but for broadcast band use the front-end would need to be track tuned.

5 comments.

The DC-80

A Direct Conversion Receiver for 80 Meters with "subharmonic" VFO in the "Polyakov" style

July 15, 2009 by Rick Andersen, KE3IJ
[Revised February 23, 2010]

NOTE: I have revised this article to include some pictures of my prototype, originally ugly-construction-only, now installed in a Mouser Electronics plastic enclosure. I have also done away with the 600 Hz CW filter; the inductor picked up too much 60 Hz AC hum for my liking, even after I took measures to kill the hum. Instead of the previous 100mH inductor and .68uF series capacitor, there is now a single 10uF electrolytic cap connecting the output of the diode detector to the input of the audio amp transistor Q2. Rather than rewrite the article, I decided to ~~cross out~~ the revised sections, followed by yellow-highlighted comments on the revisions.

You may have noticed that almost all my receiver projects on these webpages, up to now, have been based on some variation of a **Regenerative Detector**, usually a Colpitts derivative. Most QRP designs over the last 30 years, on the other hand, have favored the ***Direct Conversion*** approach, which essentially means that we inject our incoming RF signal into one port of a mixer (usually a double-balanced diode ring) while injecting a tunable VFO into the other port, with *the VFO being at just about the same frequency as the signal we want to detect.* In such an arrangement, the **beat-** or **difference-** or **INTERMEDIATE-frequency (I.F.)** is reduced to (or close to) 0 Hz -- i.e., the beat frequency is at **baseband** and is the same as the **audio intelligence**, now demodulated. So, although we can describe the Direct Conversion circuit as a sort of "superheterodyne" whose local oscillator matches the RF input frequency and therefore has an I.F. of zero, it's more common to interpret it as a "non-superhet" without any I.F. at all -- we convert the incoming signals *directly to baseband* (audio); hence the name "Direct Conversion" (also called a *Synchrodyne* detector). This is not too different from a Regen detector, in self-oscillation, very close to the incoming signal frequency, producing an audible beat note. (Another name for a Regen is an *Autodyne* detector.) In fact, it can be said that the main difference between the two is that a Direct Conversion receiver has a separate Variable Frequency Oscillator (VFO) and RF input which are then combined in a mixer; in the Regenerative receiver, the mixer/detector/oscillator are all rolled up in one stage, into which the RF is coupled. And the Regen has legendary sensitivity, but it's also more sensitive to outside influences on the oscillating detector.

While the Direct Conversion (DC) receiver is thus conceptually very simple, it also comes with its own baggage (otherwise known as "Gotchas!") that can potentially make or break a homebrew receiver, causing an unnecessary amount of hair-pulling during the debugging phase.

I've tried designing a few DC receivers over the years. In the breadboard stage on the bench, they would often appear to work great... until I put them into enclosures or hooked them up to an electrically-unbalanced antenna like an end-fed wire. That's when the trouble usually began.

The two gotchas that most often caused me to go running back to my first-love (Regen receivers) were ***microphonics*** and ***common-mode hum***, which can dampen any enthusiasm you might have for DC receivers pretty quickly. Not to say that Regens don't have idiosyncracies of their own that must be dealt with or lived with. Choose your poison. But as I often say, that's the price we minimalists have to pay for our bare-bones toy radios. But we're not fatalists; we do try to come up with tricks to minimize the gotchas ;-)

"Microphonics" simply means that, since most or all of the approximately 100 dB gain of the receiver is in the audio stages [in contrast to a superhet, where most of the gain occurs at I.F., e.g., 455 KHz in an AM table radio], the receiver becomes very sensitive to mechanical vibration, like a microphone. So when you tap the case or touch a knob, you hear a thump with a bit of bell-like resonance to it. Any wiggling of the box that causes a micro-wiggle of the turns of the VFO's coil also gets amplified; turning a speaker amplifier up too loud may also induce acoustic vibration of the enclosure and cause audio feedback that can howl like a guitar amp if not controlled.

"Common-mode hum" is a much more difficult buggar to deal with. It's a nasty-sounding, raspy 120Hz hum that appears at various points across the tuning dial, usually at the frequency you're most interested in. The mechanism that produces it has to do with the receiver's own oscillator signal radiating back into the DC power leads and being rectified in the mixer -- or something like that (look it up in a textbook on DC Receivers; I never get the explanation quite right!).

It is exacerbated by connecting your DC radio to an unbalanced antenna system, particularly end-fed long wires, Zepps, etc., whose improper installation or inadequate RF grounding might also lead to RF in the shack while transmitting. A related symptom is that your receiver snaps, crackles, and pops with every electrical transient in the house wiring, like a refrigerator compressor turning on, lights being turned on and off, etc. Sometimes you may also find a tendency for the receiver's VFO to be "pulled" excessively as you rock your antenna tuning and loading capacitors back and forth through resonance (I use a resonant antenna tuner, rather than a PI network. I like the extra rejection of out-of-band signals that a resonant tuner gives me -- essentially, it's a bandpass filter in addition to being an impedance-matcher).

So what's a DC enthusiast to do? Well, the gurus' advice to us is to:

1) switch to a balanced antenna like a center-fed dipole (I use an 80 meter full wave horizontal loop nowadays; no more trouble with electrical pops and clicks originating in household appliances)

2) try to run your QRP equipment on batteries rather than AC-powered DC supplies or "wall-warts" (I use batteries almost exclusively, yet I could still hear common-mode hum at various spots on the dial. Also, I've found that most DC power supplies that are considered "well-regulated" are just a disaster when used to power the DC receivers I've built. With all that audio gain, what little 120Hz ripple residue there is, riding on that "pure" DC output, gets highly amplified by the receiver's audio stages.)

3) put "common-mode choke" toroids in the DC power leads to present a high impedance "open circuit" path to the common-mode hum energy (didn't work very well when I tried it)

So.

This is where I can begin my story that led to the new DC receiver described in this article, which I've named the "**DC-80**."

Some years ago I was sitting at the bench, trying to design a DC receiver for 80 meters, a band I tend to favor (relatively easy to design simple equipment for this band). For my "VFO" I was using a bench RF signal generator in the usual way: tuning it between 3.5 and 4.0 MHz, which worked just fine except for the microphonics problem that I outlined above.

At some point, whether by accident or intentionally -- I can't remember -- I switched the signal generator to a lower frequency range, turned the tuning dial, and was somewhat surprised to hear some very crisp, clear SSB banter in the phone portion of... what?... the 160m band?... because the dial was set at 1.9 MHz or so. Then I realized that the front end preselect filter I had installed between my antenna wire and my diode product detector, was tuned for the *80 meter band*.... were these 160m signals blasting through the 80m filter THAT loud and clear?...

Within a few minutes of listening to the SSB'ers yammering, I was able to identify them as operating on 75 meters, not 160! I pondered this for a minute, then thought "Oh! Maybe I'm mixing a harmonic of the 1.9 MHz generator signal, not the fundamental itself, with my incoming 75m SSB stations... The second harmonic (a.k.a. "first overtone") of 1.9 MHz is 3.8 MHz, and 3.8 MHz is in the 75 meter phone (voice) band! This is kind of neat!"

Well, what was also neat was that I couldn't hear any microphonics at all, with my VFO being at precisely 1/2 normal frequency. And, being set at "160 meters" frequencies rather than directly at "80 meters", the tuning knob was less "touchy", less prone to drift, too. Very cool.

And it got late that night and I hit the sack, and that's where I left my little discovery, until recently.

The Polyakov Detector

In June of 2008, I had an email conversation with Jerry, K9UT, who had built my AGC-80 Regen and wanted me to think about a 40 meter version of that project. He also mentioned that he had been reading about DC receivers whose VFOs were set to operate at 1/2 the normal frequency, and the benefits of that configuration. As I was working on my AGC-80/40 at the time, I filed his remarks away in the back of my mind and forgot about them for the time being.

Over the past few months of 2009, I've been reading here and there about a neat little circuit called the ***Polyakov detector***, which is the circuit that I think Jerry was referring to. Also called the "Russian mixer", it is described by RA3AAE (and/or others), in its simplest form, as two antiparallel diodes (i.e., two diodes soldered together in parallel, but with their cathode bands in opposite directions). Rather than needing any broadband transformers driving them, the simplest version of the circuit has them driven by incoming RF, on one end, through a 100pF capacitor. The other end is sometimes broken apart so that a 500 ohm pot [for nulling out AM 'blanketing'] can be inserted between the two diodes' right ends; the tap of the pot goes to another 100pF cap which is the VFO injection cap (VFO energy enters the diodes through this cap); simultaneously, audio energy (the beat frequency between incoming RF and VFO) is sent out from the same point and into an R-C low pass filter which removes the RF energy and mellows the audio somewhat. From there the audio is amplified, etc. (Other, more elaborate variants of the circuit do involve broadband transformers with multiple windings.)

Further Internet surfing informed me that this circuit concept has been around for a while, and the part that makes the Polyakov detector unique is that the VFO driving it is supposed to be running at ***half** the desired RF input frequency*... the Internet sources call this a "subharmonic" mixer. And the hams and QRP tinkerers are talking excitedly about the Polyakov circuit because it apparently solves the microphonics, frequency-pulling, and "touchiness" problems of the DC receiver, to some extent, because the VFO is running at only half the usual frequency; hence, it is more stable!

While I was in that netherworld between reading about it, and getting up the gumption to go down to the shack and actually try *building* one, I pondered the actual mechanism...

Was it really the '2nd harmonic' of the VFO at 1.9 MHz that was mixing with the incoming signal at 3.8 MHz, which was the 'magic' behind this circuit's performance? Why does 2nd harmonic mixing automatically "isolate" the VFO fundamental frequency from the RF signal in such a way as to suppress microphonics, etc.? Anyway, does the presence of a 2nd harmonic mean that the VFO signal is "dirty"? Because I would expect the 2nd (and subsequent) harmonics to be several dB down in amplitude, from the fundamental, and that the injection level wouldn't necessarily be adequate for that nice, loud, crisp detection I heard during my lab bench experiment. If my VFO is too "clean", will the circuit fail to detect?

Or does even the "cleanest" VFO output sine wave get mutilated by the mixer diodes -- i.e., Does this "2nd harmonic" really originate in the mixing process of the diodes themselves, via their nonlinearity? The explanations of the Polyakov circuit that I saw attempted to correlate the dual-directionality of the two diodes with the "doubling" effect, sort of like a full wave rectifier.

Then I pondered another question I've always thought about, but have never seen a clear answer to: If I mix two frequencies in a diode mixer, unbalanced, I know I will get four freq's out: f1, f2, f1+f2, and f1-f2. The question is, do all these new frequencies also automatically mix with one another, generating higher-order mixer products (I believe they do)... so where does this stop? It would seem that the original mix would "snowball" into a near-infinite number of new frequencies being generated in the mixer...but each new frequency having less amplitude, so that the majority of the snowball would be down in the mud, for all practical purposes.

...which brought me to another thought: Hold on a minute; maybe this isn't about "harmonics" at all; instead, maybe this is about *pure **heterodyne** mixing!* After all, if I mix a 4 MHz input with a 2 MHz VFO, both being pure sine waves with no harmonics contaminating them, then our sum and difference frequencies are going to be 4+2 = 6 MHz, and 4-2 = what?...2 MHz!

In other words, the beat frequency between any frequency and its half-frequency, is *another copy of that same "half-frequency"* (i.e., its "phase conjugate"). So maybe a Polyakov mixer is not really a "subharmonic" mixer after all; maybe it is simply exhibiting a regular ol' heterodyne process where the "beat" happens to match the lower of the 2 input frequencies. In other words, a "superhet" whose local oscillator is half the input frequency, and whose "I.F." is therefore *equal to the "local oscillator" frequency*. And when THOSE TWO frequencies beat in the diode, 2 MHz minus 2 MHz = 0....Lo and behold, the output is baseband -- in the audio range!

To test this idea, I built the simple RA3AAE circuit. Then I modified it in at least 3 ways, which led to the DC-80 receiver described later in this article. The test was: Will any other, NON-Polyakov mixer perform in the same way, with *f* and *f/2* applied to their input ports?

The Polyakov circuit

It didn't seem to matter where the 500 ohm pot was set; the AM bleedthrough was still there, although centering the pot lowered the overall volume of *all* signals, desired and undesired. I'm unimpressed so far. I did try a different null pot value (1k), put it on the other end of the diodes where the RF comes in, and various other things. It worked, but not as advertised, or so it seemed to me.

A Single Diode

I took out one of the diodes. Guess what? As long as there was a resistor to ground for continuity through the diode, the circuit worked as a "normal", single-diode AM detector...*even though the VFO was running at half-frequency.* This leads me to believe that my "heterodyne" idea is correct, and that it's not necessary to have two diodes connected antiparallel, to get the "doubling" effect [which is a misnomer, in my opinion]. AM bleedthrough, however, was objectionable, which is why decently-designed Direct Conversion receivers usually use a double-balanced, 4-diode ring mixer, along with a diplexer (impedance-matcher which properly terminates the RF and suppresses it from getting into the audio amp, which can cause unwanted "AM blanketing" detection in the audio transistors' base-emitter junctions).

A 2-Diode Product Detector

Next, I tried an old product detector configuration I'd seen in the ARRL Handbooks: Solder two diodes in *series*, but in opposing polarities; put RF in the left side, take audio from the right side, and drive the junction in the middle (through a cap) with VFO energy. Well, you need terminating resistors on each diode to make this one work right. Once again, the 2-diode product detector worked well as a 3.8 Mhz detector whose VFO was running at 1.9 MHz. But still some AM bleedthrough.

A New 4-Diode Detector

Finally, I tried something that I haven't seen anyone do before: Strap another 2-diode product detector in parallel with the first, but with the relative polarities of the second set of diodes *opposite* to those of the first set. So now we have 4 mixer diodes, not chasing each other as in a ring mixer, but as 2 "series" product detectors, of opposite polarity, in parallel (see the schematic of the DC-80, below). It can also be described as 2 Polyakov detectors connected together with the VFO injection at the junction between them. (The 500 ohm balance pot is eliminated.)

I call this a ***4DPD*** [4-diode product detector] **mixer**.

And it works very well. With VFO at half the RF input frequency. So when I call this a DC receiver with a "subharmonic VFO in the Polyakov ***style***" up in the title of this article, I'm aware that it's not an actual Polyakov receiver; instead, it's based on the spirit of the Polyakov mixer, especially with its half-frequency VFO. A run-of-the-mill doubly-balanced ring diode mixer, it ain't. But it performs nicely just the same.

So, no disrespect intended toward our Russian friends, but I think the benefits of this "new and improved" Polyakov Direct Conversion approach stem from the unique heterodyne products of a 2:1 frequency ratio between RF input and VFO, not on the bidirectional transfer curves of two antiparallel diodes. At least that's my take on it, and I'll gladly retract this opinion if the facts warrant it in the future.

I learned a couple of other things in designing the new DC-80 receiver: Terminate the antenna preselector bandpass filter with a 51 ohm resistor, at the input of the diode mixer (see schematic). This seems to reduce AM bleedthrough and makes little difference in overall volume level (I thought the reduction from RA3AAE's 500 ohms down to 50 ohms would kill all my audio output. It doesn't. There's something to be said about designing around a stated impedance level, like 50 ohms.)

Also, I learned that the first audio transistor ought to be configured as a common-base circuit, whose input impedance is also low (close to 50 ohms). Not only does this seem to help with the rejection of AM bleedthrough, but it makes a surprising difference in the quiescent noise level of the audio amp, with the antenna disconnected! Some of the other projects on my webpages would probably be better performers if I had known this before this particular project taught it to me. I deliberately reconfigured Q2 as a common-emitter amp with the signal going into the base in the "normal" way we think of transistor amps being wired.....

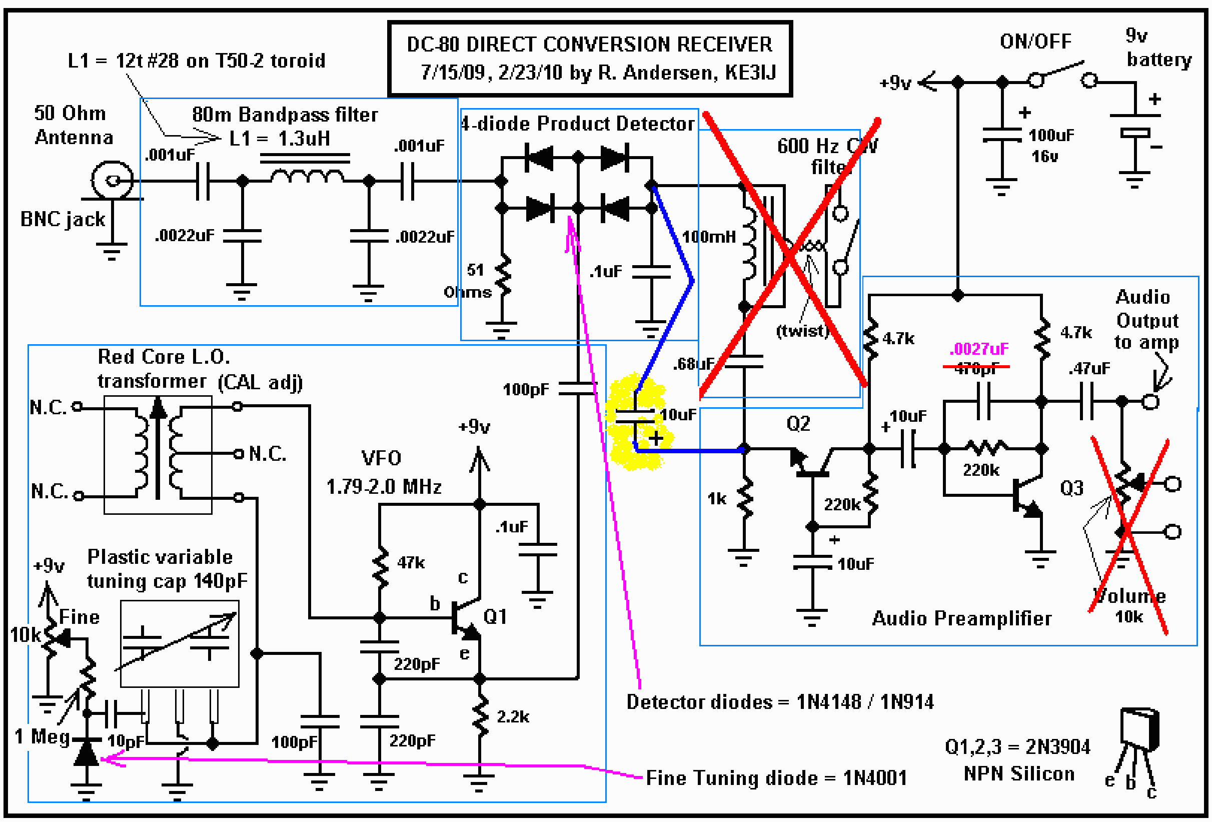
...as a common emitter amp, the receiver was quite noticeably noisy (a constant hiss) with the antenna disconnected. When I went back to the common-base setup, with audio going into the emitter, the amp quieted down to a whisper without antenna, yet was amply loud and crisp when SSB or CW signals were coming through, with antenna connected.

I'm also happy to report that there are neither microphonics, nor any common-mode hum, discernable in this receiver -- although I have not yet enclosed it in a box, which may rain on my parade, based on previous experience. The only problem I encountered was some genuine, non-raspy 60 Hz AC hum getting into the 100 millihenry inductor that I use for the CW filter. ~~I mounted it upside down so that its top was glued to the copper ground plane floor of the circuit, and I tightly twisted the short length of hookup wire coming off that inductor and connecting to the CW filter toggle switch. There was a big reduction in hum once I twisted those switch wires together. There remains a slight hum when the filter is switched to the "CW" position.~~ I eventually eliminated the inductor, .68uF cap, and CW filter switch and replaced them with a single 10uF electrolytic cap connecting detector output to audio amp input (emitter of Q2). IGNORE the CW Filter section of the schematic diagram, below.

PLEASE ALSO NOTE: Two other changes I made to the schematic below: 1) Change the 470pF ceramic cap across Q3's base resistor to a .0027uF. This compensates for the lack of 600 Hz CW filtering which I removed. 2) I removed the Volume Control pot shown in the schematic, for lack of real estate in the small box I finally ended up with. I connected the audio output cap directly to the audio output jack. A cable plugged into the jack connects to one of the infamous beige-colored Radio Shack Amplified Speakers, which is my preferred method of dealing with audio amp requirements.

Schematic Diagram of the DC-80 Receiver

Let's get into the nitty-gritty of the new Direct Conversion receiver. The schematic, below, is relatively simple, but to make things easier I have broken it up into 5 sections, outlined by the thin blue blocks superimposed over the schematic itself.



Referring to the schematic above, let's go through a description of each section:

Front End Preselector

If I can get away with avoiding large-turn coils up front, I do it. The 80-meter band front-end "preselector" filter described here was also shown as an alternate filter in my AGC-80 series of articles. It's essentially a "Pi" lowpass filter combined with series input and output capacitors, whose combination gives a sharp *bandpass* response. I designed the filter using an old version of *MicroCap* circuit analysis software which shows me a plot of the frequency response as I vary the parts values. I'm pretty sure this filter is my own invention; I haven't seen it used anywhere else. It works for me.

This configuration allows me to use fairly large caps -- .001uF and .0022uF (which are the same as saying 1000pF and 2200pF) -- along with a fairly small inductor -- 1.3 microhenrys -- which is easy to wind. Just take about 8 inches of #28 enamelled copper magnet wire (Radio Shack sells a bag of 3 sizes) and wind 10 to 12 turns on an Amidon T50-2 red-gray toroid core....which Electronix Express sells as part number 152750-2. Adjust the spacing of the turns on the coil for peak reception. Drip some melted candle wax over the windings to hold them in place, once you've squeezed or spread them for the loudest volume on an incoming signal.

The caps I use, by the way, are the green mylar caps that Electronix Express sells (I call them "chiclet" caps, because they remind me of the litte green cubes of spearmint gum that go by that name). I believe plain old ceramic caps would work, too, but I have always used the mylar "chiclets" in my designs.

The 80m filter is intended to be used with a 50 Ohm antenna impedance, and it is terminated in a 51 Ohm resistor in the radio circuit. If you want to scale the filter up or down (40m or 160m bands), you just need to calculate the capacitances and inductance from the standard formulas, and knowing the reactance values of the components, which are constant for a 50 ohm system, keeping the reactance ratios the same for all bands. The reactances are: 42 Ohms for the .001uF series caps, and 19 Ohms for the shunt caps to ground. The toroidal coil's inductive reactance is 31 Ohms.

The standard formulas are as follows:

Inductance L = Reactance XL divided by (2pi x Frequency) **L=XL/(2pi F)**

Capacitance C = 1 divided by (2pi x Frequency x Reactance Xc) **C=1/(2pi F Xc)**

So, for example, if we wanted a front-end filter for ***40 meters***, using 7.2 MHz mid-band for F,

1) the series caps at Xc = 42 Ohms would be calculated as **1/(2pi x 7.2E6 x 42)** which comes out as 5.263E-10 Farads on the calculator. Multiplying that by 1E12 converts the answer to picoFarads.... = 526pF. Since that isn't a standard value, I might try a 470pF or 560pF cap instead, and modify the turns on the coil later, if necessary.

2) For the shunt caps at Xc = 19 Ohms, the same formula gives me a capacitance of 1163pF, so I'll substitute a 1000pF = .001uF cap for that.

3) For the toroid coil, with XL = 31 Ohms, the equation would be **31/(2pi x 7.2E6)** or .000000685 Henrys, which, when multiplied by by 1E6 to convert to microHenrys, gives 0.685uH for our inductance.

But how do I know how many turns this equates to on the toroid? Well, lacking an exact formula, I can reason that, since I doubled my frequency to get from the 80 meter to the 40 meter band, and my original inductance of 1.3uH has just about been cut in half, at 0.685uH, then maybe I ought to put about half the number of turns on the toroid....I'll try 6 turns, and adjust the spacing for a peak later on when I'm testing out the receiver.

Yes, this is "designing by the seat of my pants" but it's OK; it works well enough; don't sweat it.

Notice that the coil is already less than 1uH at 40 meters. This tells me that my 'special' pi-bandpass design won't work well for any other high bands; for 20 meters I would need to change the filter design to something more conventional. But it should be OK for 160, 80, and 40.

Since my design has such easily-obtainable parts and low coil-turns, and has 50 Ohm impedance levels throughout, this also means you can cascade two of these filters in series, if you want even more out-of-band rejection. Again, simple, non-critical, and intuitive.

On another subject relating to the receiver front end:

The RA3AAE-style receiver schematic showed a transistor RF amplifier up front, before the diode mixer. I had a front-end RF amp when I first built the RA3AAE circuit, along with its 500 ohm impedances in the mixer. Bottom line, the increased gain up front invited noticeable AM bleedthrough, no matter what I tried to do to minimize it. When I remembered an ARRL publication stating that, on 80 meters at least, a well-designed DC receiver doesn't need an RF amp, I took mine out, feeding the output of my antenna preselect filter right into the diode mixer, with a 51 Ohm termination resistor to ground at that point. The result was that I was still able to receive loud signals and the AM bleedthrough was cut way down, almost to the point of disappearing, although you can still hear it occasionally when tuning to a blank spot on the dial.

4-Diode Product Detector

I've already described my experiments with the Polyakov configuration and other variations, so I'll just stick to a description of the detector stage here.

The bandpass preselect filter, just described, sees a matching termination in the 51 Ohm resistor that shunts the input of the 4DPD diodes to ground. This helps kill the "AM broadcast blanketing" that plagues simple receivers. The resistor also provides a DC path to ground between the "pumping" action of the VFO input cap, and the diodes.

The diodes, which are plain vanilla 1N4148 (=1N914) switching diodes -- nothing fancy, nor did I make any attempt to "match" them -- can be seen either as a left-hand Polyakov antiparallel pair, joined to a right-hand Polyakov pair, with the VFO injecting its signal in the middle of the two; or, one can view the arrangement as an "upper" 2-diode product detector, joined with a "lower" 2-diode product detector of opposite polarity, in parallel, with the VFO driving both their midpoint junctions simultaneously. When the polarity of the VFO signal is positive, one pair of diodes conducts. When the VFO goes negative, the

other pair conducts. Same thing as a Polyakov, but done a little differently. However you want to view this 4-diode arrangement, IT WORKS. In fact, it sounded a bit louder to me when I strapped the 2nd pair of diodes into the circuit, as if it were more efficient.

The VFO signal is coupled into the center of the detector through a 100pF ceramic cap.

The output is taken off the right side of the diode array, with a 0.1uF cap to ground, which bypasses the RF output of the mixer and leaves only our baseband audio. I tried putting another 51 Ohm resistor in series with that cap to ground, in an attempt to imitate one of the "diplexer" circuits I found online in a "DC 'Popcorn' Receiver" schematic, but there was noticeable AM bleedthrough(!) When I removed the resistor and put the bypass cap straight to ground, the AM stuff disappeared. Go figure.

For those of you whose 'common sense' tells you that 0.1uF is much too large a cap to use -- that it will make the audio sound too mellow... -- Surprise! -- it's not like that when you're living in a 50 Ohm world! That 'common sense' only works when your "background" impedance is up around 1K to 10K. The signal is still quite "tinny" at the output of the 4DPD, and needs some more mellow-out filtering later on, in the audio amp. (I bring this up because I once came across a pair of pundits critiquing one of my radio circuits on some blog somewhere. They applied the standard "f=1/(2piRC)" roll-off formula to my component values and concluded that my audio must be as mellow as jello because my bypass cap appears to be way too big. Not in a low-impedance circuit, though. Hasn't it ever occurred to you to wonder why the coupling cap feeding the 8-Ohm speaker in an audio amp has to be way up there around 470uF or more? You need to dump more charge through a smaller resistance in order to get the same power.)

But I digress.

"Subharmonic" VFO

We leave the mixer/detector output for now and travel down to the VFO.

As any good Ham knows, the VFO can make or break a receiver. So let me say right here: *I wanted a quick and dirty, functional VFO; simple and cheap.* So I used only a single stage, with no buffer. I basically took a Clapp Oscillator design and used the perfect "coil" for that oscillator, at 1750 - 2000 KHz..... one of those little oscillator cans with the red screwdriver-adjustable cores, which tunes the Local Oscillator (L.O.) in an AM broadcast radio. Voila! No coils to wind with dozens of turns at 160 meters. Because -- remember -- we are running the VFO *Polyakov*-style, at 1/2 the RF input frequency.

To make things simple for me and for you, I also borrowed the variable tuning capacitor from cheap transistor AM radio design -- one of those little plastic-cased tuning caps with the 3 leads coming out the side. Unlike the metal-plate 365pF variables of the days of yore, these plastic "polycaps" have a total capacitance of around 140 - 170 pF for the RF section, 60pF or so for the L.O. section [intended for a superhet receiver]. I soldered the two cap sections in parallel (the outer leads) while grounding their bottoms through the center lead. Then I also have a 100pF cap in parallel with the whole thing, and series connected 220pF's as the feedback caps in the base-emitter circuit of the 2N3904 transistor, Q1. These values were obtained by experiment and could be improved upon. In fact, the whole VFO was hastily designed and could be improved upon. It's a bit drifty in frequency, but it works! Without taking any "dBm" measurements, it provided a very adequate injection level from the first moment I turned the radio on, as evidenced by the crisp, loud signals I'm able to hear, and by the relative lack of "spurs", "tweets", and unwanted intermodulation products.

So there! If you don't like it, make it better! I'm admitting that I scrimped where I probably should have been a lot more careful.

2/23/2010 Revision: Added a Fine Tune "Clarify" Control

The right-most knob on the front panel of the encased DC-80, which you'll find farther down the page, is the Fine Tune pot. It operates like the Bandspread tuner in old shortwave radios, and like the "Clarifier" knob on some old CBs. In a nutshell, the 140 pF plastic tuning cap tunes the whole 500 KHz -- 3.5 to 4.0 Mhz -- of the 80 meter band. With no gear reduction, one half-twist of the knob covers the whole band in one fell swoop, and the tuning rate is too fast for comfortable operation. I've added a parallel "fine tune" which is a 10k potentiometer controlling a reverse-biased rectifier diode, used as a varactor tuning diode. The 0-9v at its wiper is isolated from the VFO through a 1 Megohm resistor, and lightly coupled to the top of the plastic Main Tuning cap via a 10pF ceramic cap.

To operate, start with the Fine Tune knob set in the center of its range. Tune in a station with the Main Tuning cap, and tune for a 'zero-beat' with CW signals, or, tune for a deep growl on SSB voice signals. Now, turn the Fine Tune left or right until the "growling" SSB voice "clarifies" to a normal pitch. If tuning CW, tune to the desired beat note.

Since one of the distinctive traits of a simple Direct Conversion receiver (or Regenerative receiver, for that matter) is that it lacks *single signal* capability (i.e., you are able to hear the signal on **both** sides of "zero-beat"), you will be able to tune SSB voice signals either "correctly" or "backwards"--- if you're on the "left" side of zero-beat, the voices will sound garbled and impossible to understand [because of audio spectrum inversion of the sidebands]. Turn the Fine Tuning control clockwise through zero-beat, and you will end up on the "right" side and will be able to hear intelligible speech, although it will vary from a deep/low sound to a high "chipmunk" sound; somewhere in the middle of that range you will hear a normal-sounding voice. The Fine Tune pot helps you clarify that voice with a slower tuning rate.

~~Switchable CW Filter~~

~~Back up to the output of the mixer/detector:~~

~~I use one of the small, cylindrical blue inductors from Electronix Express in a series bandpass filter, as my very simple CW filter [the inductor also blocks any RF that the 0.1uF bypass cap may have missed]. The choke (as they call it) has a value of 100 milliHenrys, with a DC resistance of around 100 Ohms (they must have a lot of turns of very fine wire inside). That 100 Ohms knocks the Q down, making a rather broad filter, but it's adequate for such a simple filter. The other component making up this filter is a mylar cap whose value I have listed on the schematic as 0.68uF; this value, along with the 100mH choke, gives a resonant peak at around 600 Hz. If you prefer a 750 Hz peak as many QRPers do, change the cap to 0.47uF.~~

~~A toggle switch is wired across the 100 mH choke. When the switch contacts are OPEN, the choke is in-circuit and you're in 600 HZ "CW" filtering position. When the switch is CLOSED, the choke is short-circuited and the audio signal travels straight from the detector output to the 0.68uF cap, which doubles as a blocking/coupling cap for the input of the audio amp, Q2. With the choke out of circuit, the audio is unfiltered and quite "bright" [tinny-sounding], to be mellowed out just slightly in the audio preamp circuit, described in the next section.~~

~~One "gotcha" that I experienced with the 100mH choke inductor was that it picked up a healthy amount of 60-cycle AC hum from the soldering iron. I mounted it upside-down, gluing it to the copper ground plane on which I built the prototype (see picture near the end of article). The hum got worse when I wired the CW Filter switch across its leads. I then twisted the two switch wires together, which killed most (not all) of the hum. Your mileage may vary, so keep the physical distance short between the choke and the panel-mounted CW Filter switch, and twist the two wires leading to the switch, tightly, down their length.~~

Quiet Audio Preamp

Well, a lot quieter than some I've built, anyway.

As usual, I built this receiver without an audio power amp. Instead, I route the output to a Radio Shack Amplified Speaker (steadily rising in price; now about $14.99 I think; I'd like to believe that all my articles extolling the virtues of this little amp has caused business to boom for Tandy Corp.; at any rate, I remember these little beige boxes costing around $11.99 back when I started this website) and lately I've been plugging a computer speaker into the aux output of the Radio Shack amp for better sound.

As I've described elsewhere in this article, I discovered that this receiver's quiescent noise, heard when there is no antenna connected, was drastically reduced when I compared Q2 wired in a common-base configuration, with Q2 wired in a common-emitter configuration. I'm not sure of the correct explanation, other than to say that in the common-base circuit, the input impedance is low, giving a good match to the 50 ohm level designed into the receiver front end.

~~The same 0.68uF cap [or 0.47uF alternate] that serves as the capacitive element in the L-C CW Filter, also serves to couple the weak audio from the detector into the emitter circuit of Q2, a 2N3904 like I always use.~~ I now use a 10uF electrolytic here.

The cap serves to block DC at the same time; there is approximately 1 volt DC at the top of the 1K emitter resistor, and we don't want that bias to affect the diodes in our mixer. So we "cork it up" with that cap, which serves to "couple" AC (audio), while "blocking" DC (Q2's emitter voltage). [I used to tell my electronics students that a cap passing AC while simultaneously blocking DC is like waving at someone through a glass window: They can see an image and movement (change; AC) but if you try to blow a stream of air at them, the glass blocks the flow (flow; DC). I'm sure that that explanation caused less brain damage than a friend of mine did when he used to play mind games with his young boy by shaking his head up and down when he meant "No", and side to side when he meant "Yes". The kid is probably doing prison time by now.]

A 220k resistor supplies positive current to Q2's base, while a 10uF electrolytic cap bypasses any audio on the base, to ground. Doing this forces the collector to output an amplified version of the audio variations coming in at the emitter. The amplified audio is picked off Q2's collector and 4.7k collector load resistor, coupled to the next stage through another 10uF electrolytic, and sent into the base of Q3 for further audio amplification. Q3 is grounded at its emitter (a common-emitter configuration) while the base is supplied with DC bias through another 220k resistor. Both stages connect their base resistor to the collector; this is known as "collector biasing" and is a form of negative feedback that automatically sets the transistors' bias at the optimum operating point in their bias curves.

Notice that there's a ~~470pF~~ .0027uF cap across Q3's base bias resistor. This is a bit of "mellowing" for the tinny-sounding audio I mentioned earlier; a simple low-pass filter to take some of the edge off the highs... so that the piercing whistle of W1AW's code practice signal doesn't drive you batty even when tuned 8 KHz away!

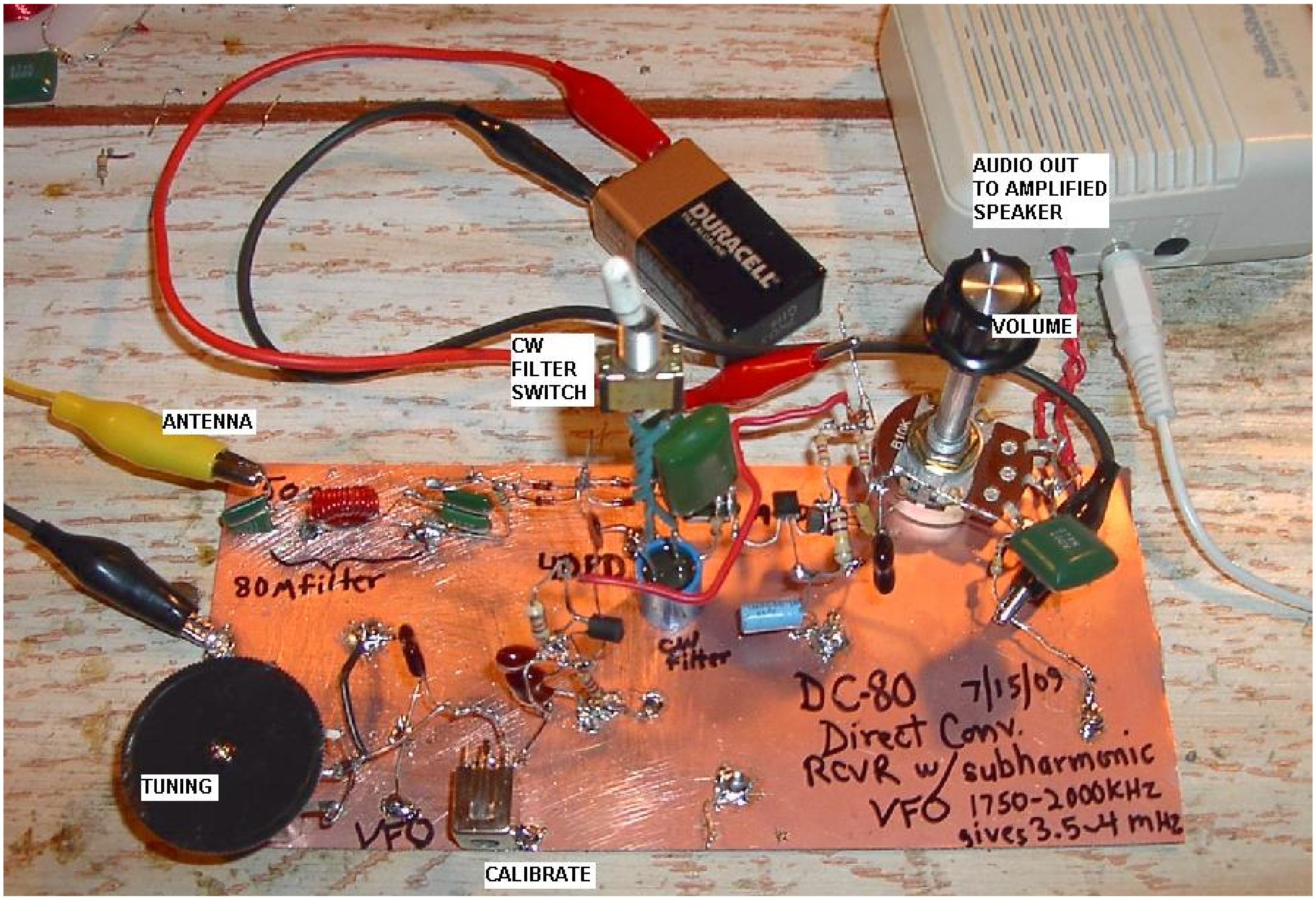
But note that when the CW Filter switch is "off" -- shorted, actually -- the only filtering that the audio sees is that of the 0.1uF cap at the detector output, and this ~~470pF~~ .0027uF cap across Q3's base bias resistor. So the guys on SSB and AM phone sound sharp and right there in the room with you... and static crashes are that much more noticeable, ~~whereas in the CW position, static is greatly reduced by the action of the 600 Hz bandpass filter, and the extremely high-pitched CW tones are mostly filtered out.~~

~~At the collector of Q3 we couple the audio out to a 10K potentiometer (Volume Control), which is a variable resistance voltage divider whose wiper connects to the audio output jack. High-impedance crystal or magnetic headphones may be connected here, although I prefer to connect my amplified speaker here instead. You may ask why I put in a volume control, if the Radio Shack amp already has one at its input? The reason is that there is a lot of amplification (audio gain) from Q2/Q3, and the Radio Shack amp was actually being overloaded, during the peak of the SSB yakking hours in the evening, even with the amp's volume control turned almost all the way down. This made me happy, because as a seat-of-my-pants designer, I knew that enough audio to overload the Radio Shack amp was certainly enough to drive most headphones to at least adequate volume. (Since I don't have a pair of decent 2000 ohm headphones, I have to make educated guesses about how the receiver will sound to someone who does have them ;-)~~ I left the Volume Control out of the revised version because it would not fit in the

small enclosure from Mouser (although they do sell larger versions of the box). I made the decision to simply send the strongly-amplified audio to the rear audio jack, and to let the volume control on the Radio Shack Amplified Speaker suffice as my gain control. If you decide to build the DC-80 in a bigger box, you may decide to put it back into the circuit.

A Picture of the Prototype

It's ugly! -- it's scary! -- it's coming to a theater near you -- it's not in an enclosure yet! -- but here it is. I've marked the major components with labels or with black magic marker on the copper-clad board. If you build it and it starts giving you trouble in an enclosed box like some of my earlier DC receivers did, you have the right to box my ears and pommel me. But I wanted to get the new design up as soon as I could. If you look closely at the picture of my prototype, you can see that there's really not much to it, that it should work as well as it does. This 1/2 frequency VFO thing really seems to have breathed new life into the lowly Direct Conversion Receiver. Build one of your own, and if you don't think it performs, look at it as a learning experience.



2/23/2010 UPDATE: The DC-80 in an Enclosure

Mouser Electronics to the rescue! I found a cute little "bone-white" plastic box in the Mouser catalog, part number 616-79160-510-039, which is a small 4" x 6" x 1.5" high plastic box with top and bottom pieces, plus removable front and rear plastic panels that fit in grooves between top and bottom sections. The top and bottom are held together with long screws that go in through the bottom. The enclosure comes with 4 press-on adhesive rubber feet. Only $7.70 + shipping at the time of this update in February 2010.

Here are some photos of the DC-80, rebuilt on a small copper ground plane and mounted in the Mouser box:


DURACELL


DURACELL

PARTIAL Parts List

I'm not gonna give you part numbers for every resistor and cap in the circuit. The resistors are 5%, 1/4 watt types and most of the caps are the green mylars. The big cylindrical caps with polarity markings are electrolytics and should have a DC working voltage over 10v. The VFO injection cap happens to be a 100pF ceramic. You can go to the Electronix Express website and browse their online catalog for yourself. But the 'unique' or unusual parts are listed here, for your convenience and abatement of confusion.

I've decided to give Electronix Express a big plug in this article, since I've dealt with them before and found that they almost always have the kinds of components I need for QRP radio projects -- like the inductors and variable capacitors. Sometimes a few of their parts are back-ordered and take a while to arrive, but for the most part, my orders arrive at my door within a week. (I used to teach Electronics at ITT-Tech, and Electronix Express -- under their alternate name, RSR Electronics -- was our source for electronic parts and kits used in our Lab courses.)

Front End

Antenna connector - BNC female, panel mount. You'll notice in the picture that my prototype doesn't use one, but uses alligator clips instead. Well, when I put it in a box, I'll use a BNC connector, OK?

L1 = 1.3uH coil. Wind 12 turns #28 magnet wire on a T50-2 toroid core (Electronix Express # 152750-2) and adjust turns spacing for loudest signals in the middle of the band (windings cover about 1/3 of the core).

Caps = green mylar types at Electronix Express

Detector

Diodes = 1N4148 / 1N914 silicon switching diode

VFO

Q1 is 2N3904 NPN silicon, like I use in most of my projects.

Transformer is the red core Local Oscillator "can" that is used in most transistor radios. Electronix Express # 16IFR, or Mouser/Xicon 42IF100-RC.

CALIBRATION: Set a nearby receiver to 2.000 MHz, and, with the DC-80's tuning cap turned fully clockwise (top of band; least capacitance), use a screwdriver to adjust the red core until a loud "whoop!" is heard in the 2 MHz receiver. This sets the top of your DC-80 at 4.000 MHz (top of the 75M band), with the VFO running at half the RF input frequency. Re-calibrate if the bottom of the 80m CW band falls out of range, if needed (i.e., the receiver may not tune the entire 3.5 - 4 MHz band, depending on parts tolerances, etc.)

Tuning capacitor is Electronix Express p/n 14VCRF10-280P, the typical AM transistor radio plastic tuning cap with 3 leads. In this receiver we connect the two end leads together (connects to L.O. transformer) while grounding the middle lead.

~~CW Filter~~

~~Inductor is a 100 millihenry cylindrical choke, Electronix Express # 150100M.~~

~~CW Filter switch is SPST toggle or slide switch, whichever floats your boat.~~

Audio Preamp

Q2 & Q3 are 2N3904 NPN silicons, like I use in most of my projects.

Volume Control = 10k Ohm potentiometer with ON/OFF switch, Electronix Express # 18PMS10K

Power & Miscellaneous

9 volt battery

Battery clip

100uF, 16vDC electrolytic capacitor (bypasses entire receiver, preventing motorboating oscillation)

Final Comments

~~The receiver needs a "Fine Tuning" control. This could be a small-value variable cap strapped across the Main Tuning cap in parallel with it.~~ The single, miniature plastic variable cap knob has no gear reduction or vernier action (obviously) and it's hard to properly "clarify" SSB voice signals. There's also some body capacitance effect with the circuit unenclosed. Tuning is pulled off frequency when you've zeroed in on a station and then taken your hand away.
Added a Fine Tune "Clarify" Pot; see above.

There is still some discernable AM bleedthrough, but not much at all. It's much easier to mentally screen it out with this receiver, compared to, say, a *Pixie* or other simple Direct Conversion receiver which lacks a double-balanced diode ring mixer up front.

The receiver could also use some form of AGC, like I use in the AGC-80 series. But, as I said, this prototype was meant to prove the 1/2 VFO frequency concept of the Polyakov-style mixers; these other comments are refinements for another day.

If you decide to put one of these simple receivers together, I'd like to know how yours works out. Email me at rick@ke3ij.com

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Ugly/Ground Plane Construction

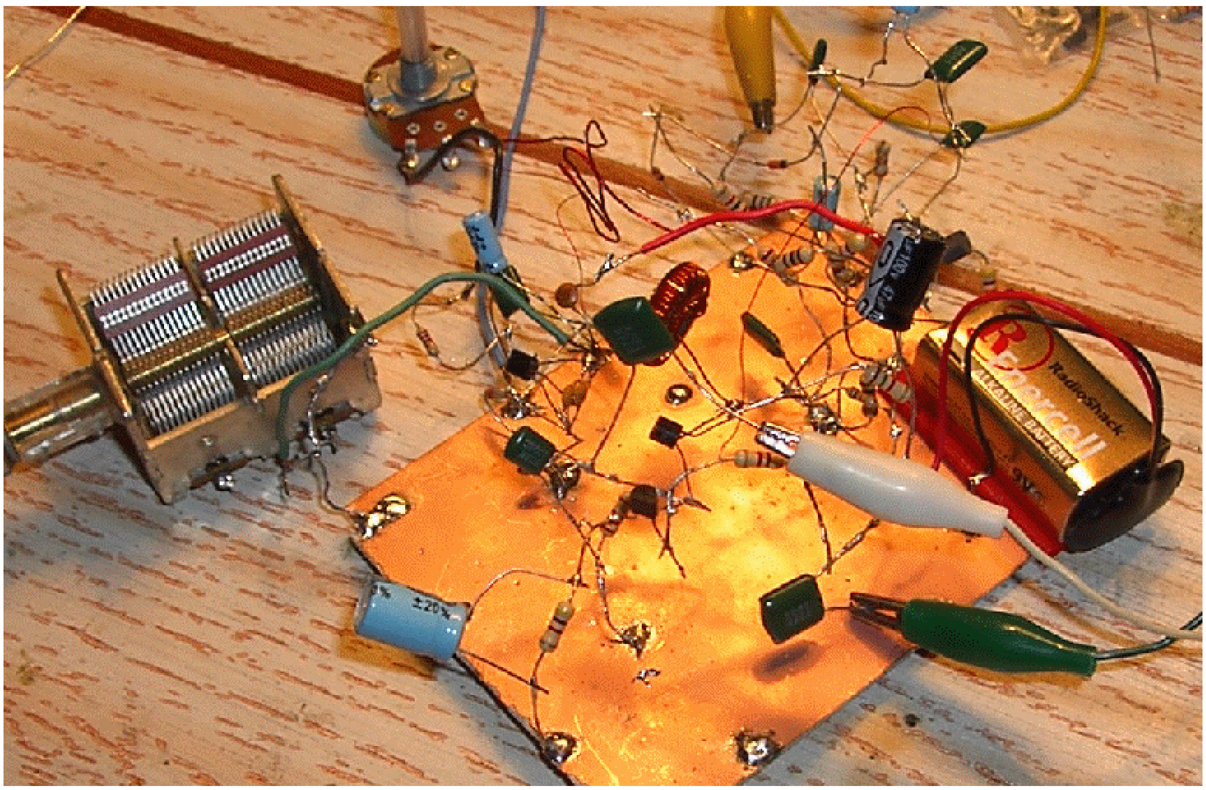
The Method I Use in Building My Simple Receivers

Oct. 7, 2006 by Rick Andersen, KE3IJ

Occasionally I get emails from readers who want to know how I build these simple radio receiver circuits on an "L-shaped chassis" without cutting and scoring the copper, what I mean by "L-shaped chassis," or "what's all this about 10 megohm resistors?", etc. I tend to forget that not everybody has done this before, and I usually take it for granted that the reader is an accomplished "basement-tinkerer" and should therefore be able to just look at a schematic diagram and then come up with his own layout and method of construction. Sorry if I have annoyed anyone -- that wasn't my intention.

When I first design a circuit, I make what a friend of mine used to refer to as a "spider" (or, "spider-web")-- basically just construct the circuit by soldering the components together, lead by lead, into a reasonable facsimile of the schematic (no chassis or pc board necessary-- the stiffness of the soldered leads themselves hold the "spider" circuit together). This method is quick, and allows me to modify things fairly easily. It also grows rather quickly into a "haywire monstrosity" if I allow it.

Sometimes I do use a piece of copper-clad pc board as a ground plane, even during the "spider" stage, as the photo below illustrates:



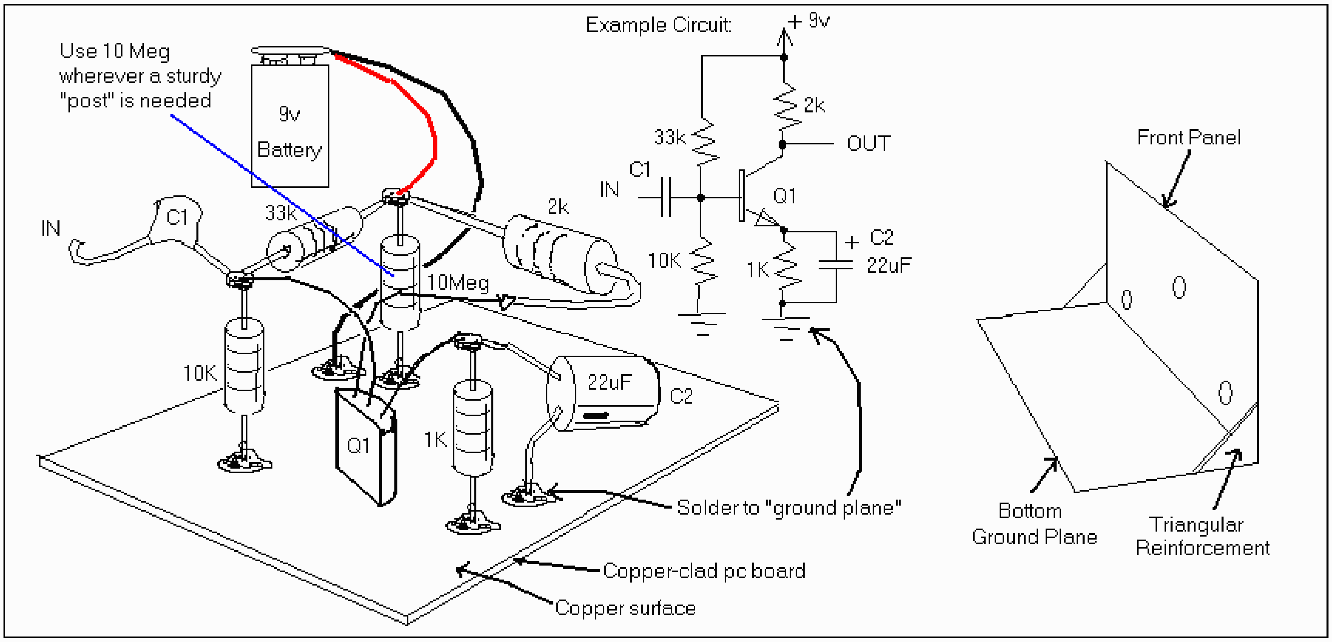
A "haywire" mess of my "AGC-80" Regen receiver in its early, experimental stage

To make things a bit clearer to you who have never built projects in this way before, I have attempted a free-hand diagram using Microsoft "Paint", which I converted to a .gif file and which you see below.

In the top-center of the diagram is the schematic for a simple common-emitter audio amplifier stage. The left side of the diagram illustrates how one might translate that schematic into an actual circuit on the copper-clad pc board. At right is a diagram of the "L-shaped Chassis." This is the style in which I build most of my circuits.

Basically, I use 2 pieces of 5x7 inch copper-clad pc board, available in the USA at **Radio Shack** [free plug]. One piece lies flat (the bottom piece), which is what I have shown in the diagram. I build my circuit on this bottom piece, using the copper floor as my ground connections ("ground plane"). Any resistors, caps, etc., that go to ground in the schematic, are literally soldered to this bottom ground plane and stood upright. At their top ends, the rest of the circuit is soldered, suspended up above the ground plane. Anywhere that I think I need some mechanical stability, I use a vertical 10 Megohm resistor, which acts to prop up and support the rest of the wiring above the ground plane. For most of the circuits I build, 10 Megohms is much higher a resistance value than any of the resistors in the circuit itself; therefore, the circuit pretty much ignores the 10M "posts", electrically, and they remain simply a mechanical "standoff insulator". The 2nd piece of copper clad board is drilled for switches, potentiometers, tuning caps, and earphone jacks, etc., and then is soldered at right

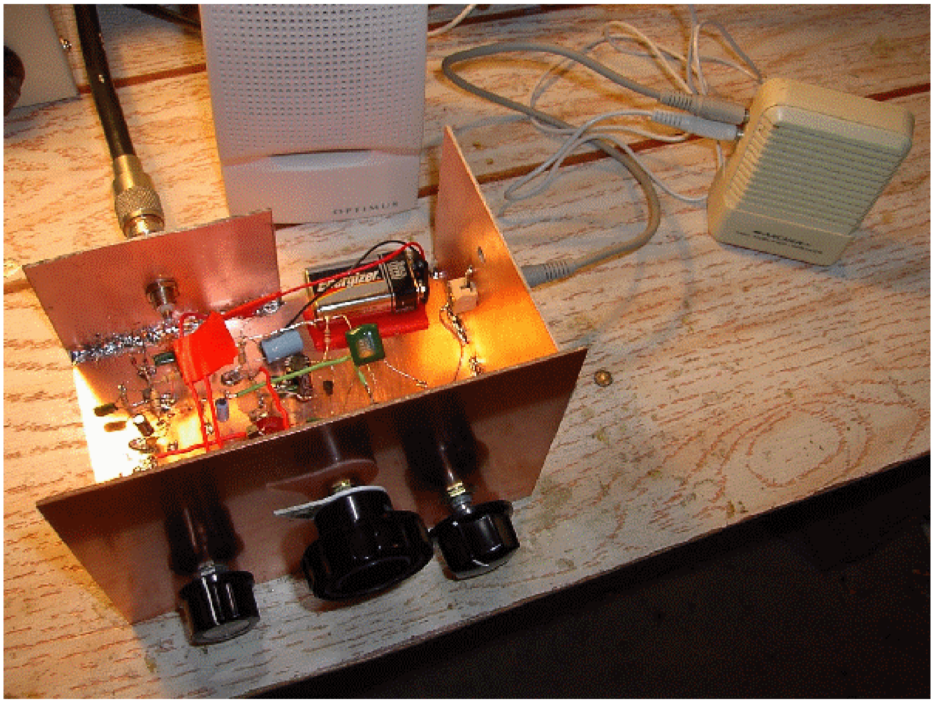
angles to the flat bottom piece, making an "L-shaped chassis". It also helps to solder triangular pieces of copper-clad board as mechanical braces, at the corners where the front panel is soldered to the bottom ground plane.



Below is a photo of my 2006 creation, the "AGC-80", a Regen receiver for the 80 Meter ham band with audio-derived AGC. There's an article on this receiver elsewhere on this website; meanwhile, notice that it is built in the same way outlined above-- an "L-shaped" chassis made of a bottom piece of copper-clad board, soldered to a vertical piece of the same kind of board which is the front panel. [I also added a back wall to hold the antenna jack, and a right wall to hold the audio output jack, as well as a triangular reinforcement piece of copper-clad, at bottom-left between the front panel and bottom piece, although you can't see it in this photo.]

To the right of the AGC-80 is the infamous Radio Shack/Archer little beige Amplified Speaker that I'm always mentioning. I may knock Radio Shack for other reasons [for example, that they have pretty much left us hobbyists behind, and have become just another consumer electronics store] but I will always say good things about their little $12.95 beige-colored Amplified Speaker. It works like a charm for the kind of projects I build. I also run an audio cable out of the Radio Shack amp to a bigger speaker, for better-quality sound-- in the photo you can see a white "Optimus" computer speaker pressed into this service. While the Radio Shack's speaker does a fine job, the Optimus sounds quite a bit louder and way nicer. Of course, you may argue that a *real* Electronics Geek rolls his *own* audio amp rather than rely on a commercially-made, external one. Well, I'm often too impatient to build the audio power amp myself, after having spent hours or days getting the RF part of the radio to work the way I want. Also, homemade audio amps tend to oscillate (squeal, motorboat, howl) in mysterious ways once lovingly installed on the same circuit board as the RF circuitry.... After a while one grows tired of trying 50 ways to make it happy, and would rather just hook up an Amplified Speaker and be done with it.

To each his own.



Please realize that you don't have to follow this method of construction (usually called "Ugly Construction" by hams), but I would advise you to make sure there is some equivalent of a copper ground plane in most of your radio projects... it helps to shield the circuit from outside influence (particularly when connected to earth ground) and contributes to stability.

I hope this has helped to give you a little better idea of the methods I use!
73 de Rick, KE3IJ

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Alan's Lab

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Multimeter RF Power Add-On

2007-09-09

Being able to quickly measure RF power from -10 dBm to + 30dBm is extremely useful. This simple 50 Ohm load with inbuilt diode peak voltage detector fits the bill. Unfortunately it must be calibrated carefully and isn't direct-reading, but a simple table of Voltage or Current measured to delivered dBm can be constructed and kept near the unit.

I wrote a short program to generate a table of the Voltages, RMS, Peak and Peak-to-Peak that represent -20 dBm to +30 dBm. The formulae might be simple, but the table is useful for ball-parking, and was used to calibrate the meter at DC.

Calibration at DC isn't perfect, RF will read slightly differently as the dynamic properties of the diode vary. However it is extremely easy to just dial up DC voltages on your bench PSU and write down the corresponding reading on the multimeter.

If you use 75 Ohms more than you use 50 you might build and calibrate yours for that impedance. The load resistors will tend to dominate the frequency response, but the detector itself does affect the high-frequency return loss. The resistors and layout I used are only really suitable to low VHF, but for my immediate uses that is sufficient.

Build yourself a diode probe too (there is a 470p chip capacitor hidden under the wires).

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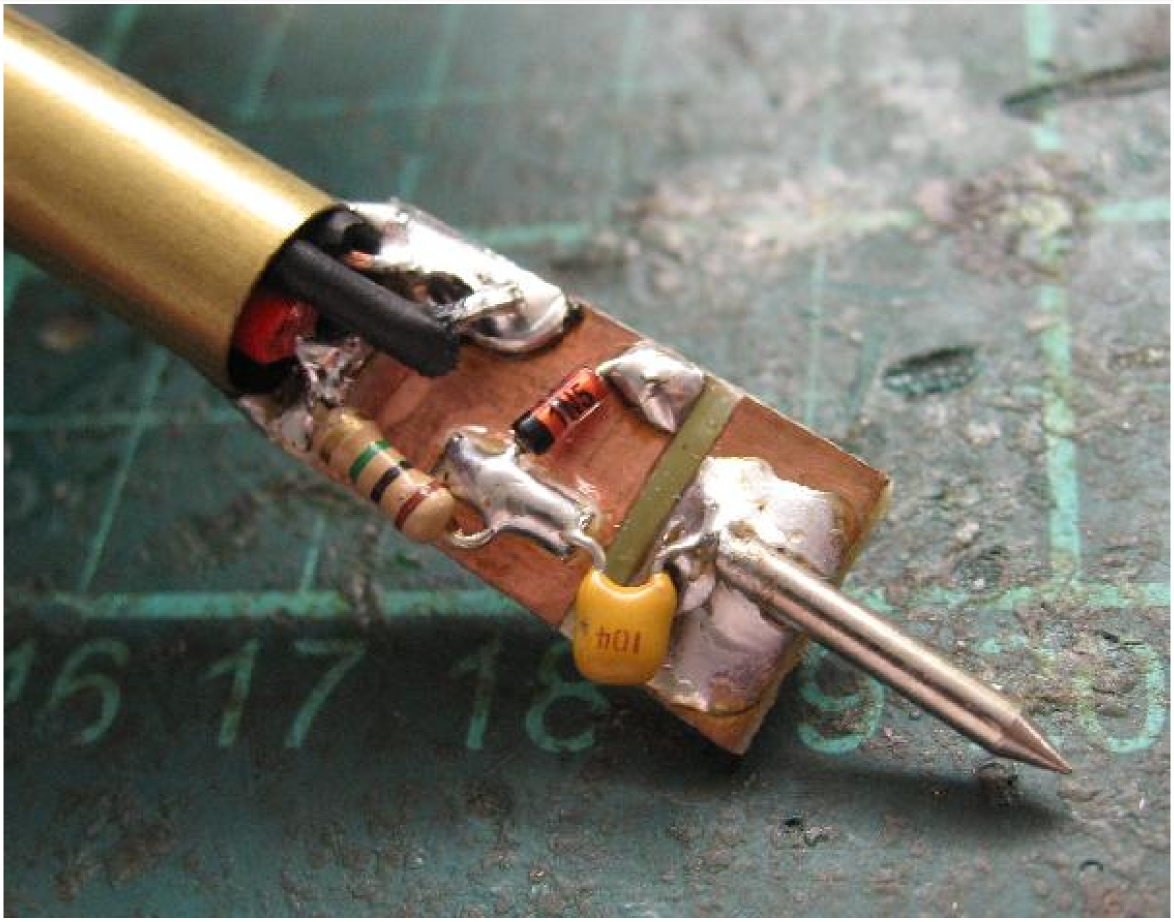


Unlike the power meter the diode probe is designed to only load the circuit very lightly, measuring the peak RF voltage at the point under test. As the impedance of the particular point in question will vary it can only use used for relative measurements so there is little point calibrating it.

Notes

The diode is a 1N5711.

The 10 nF capacitor directly across the meter plugs is to prevent RF from upsetting the meter (smaller values using ceramic or chip caps might be more appropriate at higher frequencies). The budget meter show is actually very resistant to RF interference compared to some of my other multimeters, my old DSE Q-1418 did not like the RF at all once more than a few dBm was delivered. (Meter show is a Jaycar QM-1500, about $8 AUD. For the price you may as well just dedicate one to this service.)

The 1 KΩ resistor in series is to limit short-circuit currents to something that won't zap the diode. It is small enough to be effectively ignored when looking at the peak voltage with the high input resistance of a modern multimeter. It also allows you to use a current measurement instead, either with a mechanical VOM or bare meter movement, or with the multimeter. Your multimeter might work better in this mode. It can't hurt to produce a calibration for current too, so you can compare the measurement of voltage and current if something looks weird. (i.e. If you have your doubts about RF upsetting the meter due to an unexpected resonance.)

4 comments.

Attachments

title	type	size
RF Power Table Generator Source in PHP5	text/plain	1.082 kbytes

The Fredbox

2007-05-26

I first heard about The G3XBM Fredbox transceiver via Solder Smoke. As soon as I saw it I just had to give it a go. It is a very simple and elegant design. Of course it offers no bells or whistles, just a fixed TX and RX frequency, and a flea-power output on TX, but it has a special charm in its simplicity and the retro usage of AM on VHF.

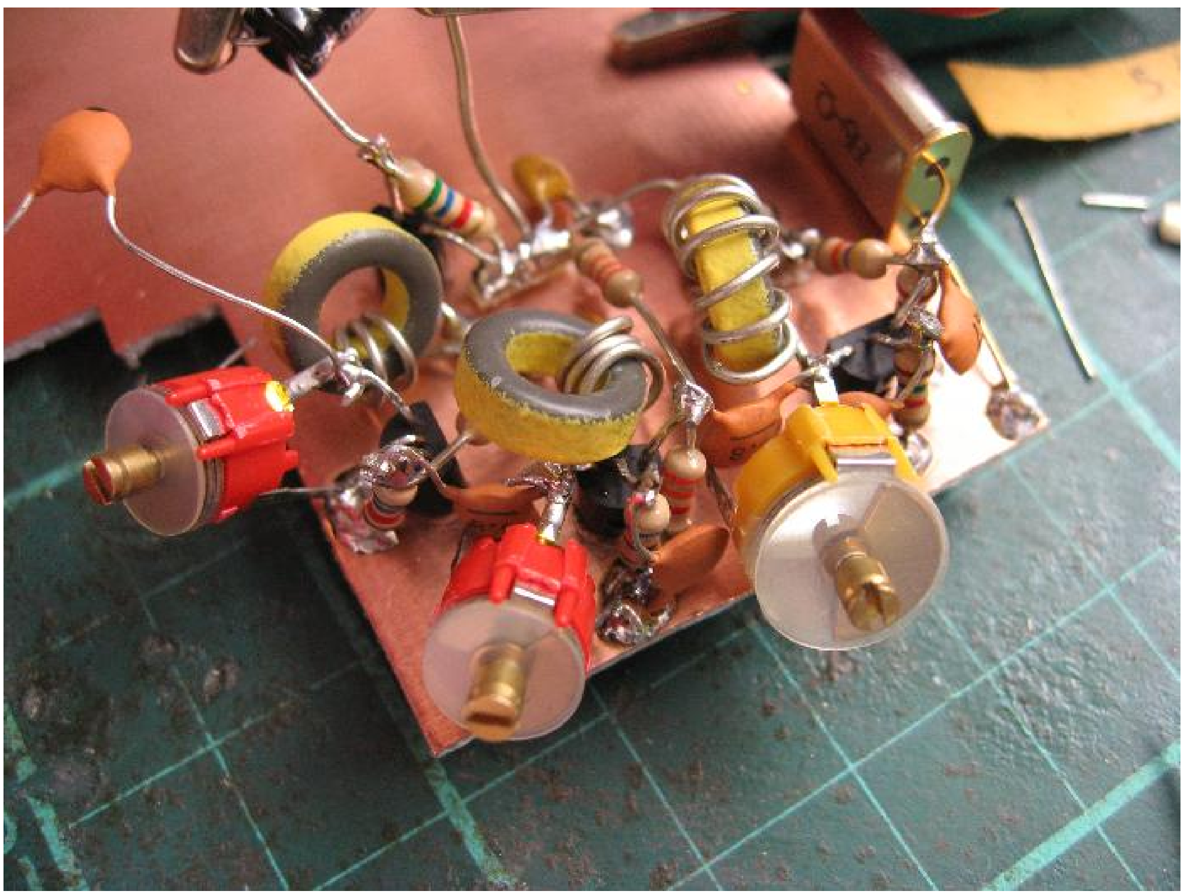
Transmitter

I built the transmitter side first. BF199s were selected as a good candidate for the RF devices, but I lacked a crystal in the range specified in the original article. Instead, I used a common 16.384 MHz crystal and redesigned the circuit to be two triplers rather than two doublers. This crystal is a common "computer" crystal, but places the TX frequency in the high-end simplex segment. This is a bit too close to the pager-splattered end of the band for my liking, and doesn't match the band-plans. For now this is OK, I'll get a custom crystal cut eventually.

I didn't use shielded cans or variable inductors for the transmit coils (as specified by the article), rather I used fixed inductances wound on T37-6 toroid cores with bare 0.71 mm tinned copper wire. My LC resonance calculator and nH inductance meter were enormously helpful in making the selection and testing of the tripler and output stage resonators. Each stage was tuned with trimmer capacitors.

It was amazingly easy to get the TX-side working, I just built each stage from the crystal to the final amp in turn, testing as I went. Each stage is well behaved and peaks nicely.

Peter VK2TPM could hear the signal at his QTH several kilometres away when I connected the half-finished TX board into my flower-pot antenna. The DC input power was about 23 mW, and no special attempt was made to match the output into the load, in fact the series trimmer in the matching network was absent at this point, just a fixed 12 pF capacitor was used for DC blocking.



Upon finishing the TX circuit I did experience a bit of RF pick-up in the microphone amplifier 2nd stage. A 1 nF capacitor to ground discouraged its RF gain and eliminated the problem. The 2nd AF amp stage is located immediately adjacent the crystal oscillator stage and was picking up RF directly. The effect was not audible, but was visible on the spectrum analyser as weak 16.384 MHz sidebands either side of the carrier. This wasn't causing feedback, just high-frequency modulation of the signal. If nothing else it proved the bandwidth of the modulator, which is perhaps a surprise considering the 100 nF decoupling on the modulated rail, however the output impedance of the series modulator emitter is so low it could deliver a few tens of mVs of HF ripple into that kind of load.

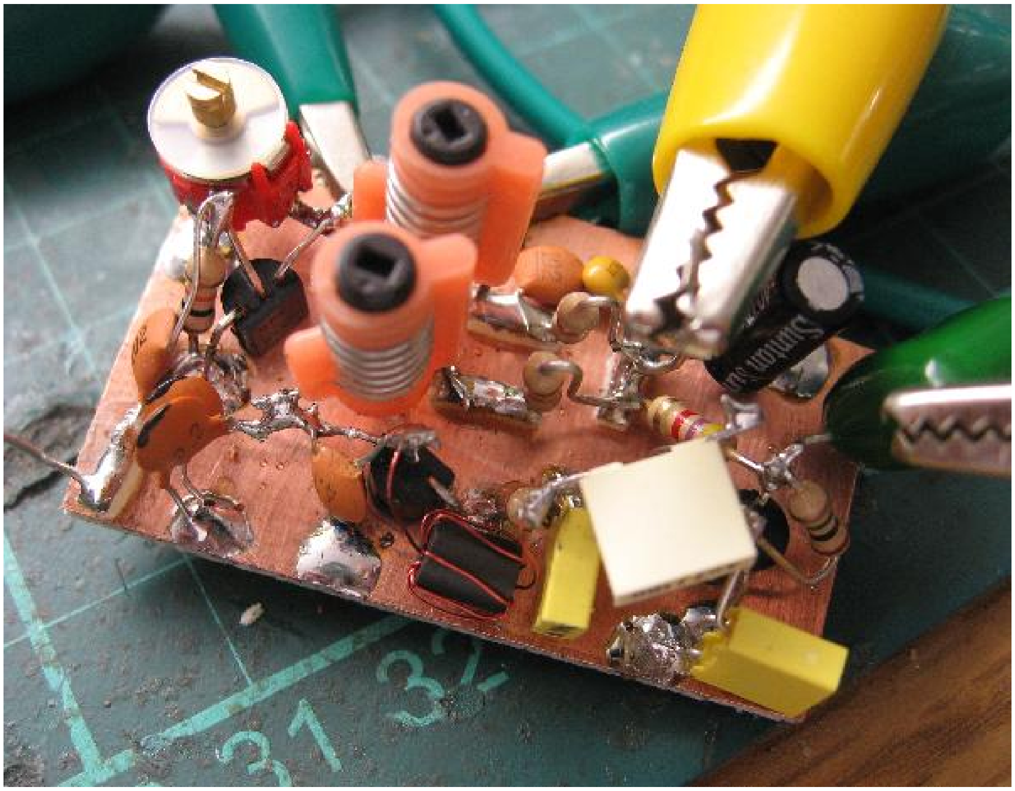
Receiver

As easy as the Transmitter was, the Receiver was hard. It fought me every inch of the way. I spent an entire day trying to work out why it was simply not super regenerating from about 130-160 MHz. It turned out to be a 10 nF decoupling capacitor on the cold-end of the detector resonator. The article specified 1 nF, and I originally intended to use this value, but I had a strip of 10 nF mono's on the bench, so I used them. At build time I did consider why 1 nF was specified in the first place, I figured it was avoid the exact problem that would befall my unit, decoupling resonance. (Lesson #1: Trust the original builder and your initial instinct.) When the unit wouldn't oscillate properly I assumed that I had damaged the capacitor on install - this is a pretty common fault, so I tested it in-place by ensuring it would shunt a HF signal (my standard decoupling cap test), it passed this test just fine. (Lesson #2: Test at the frequency of operation.)

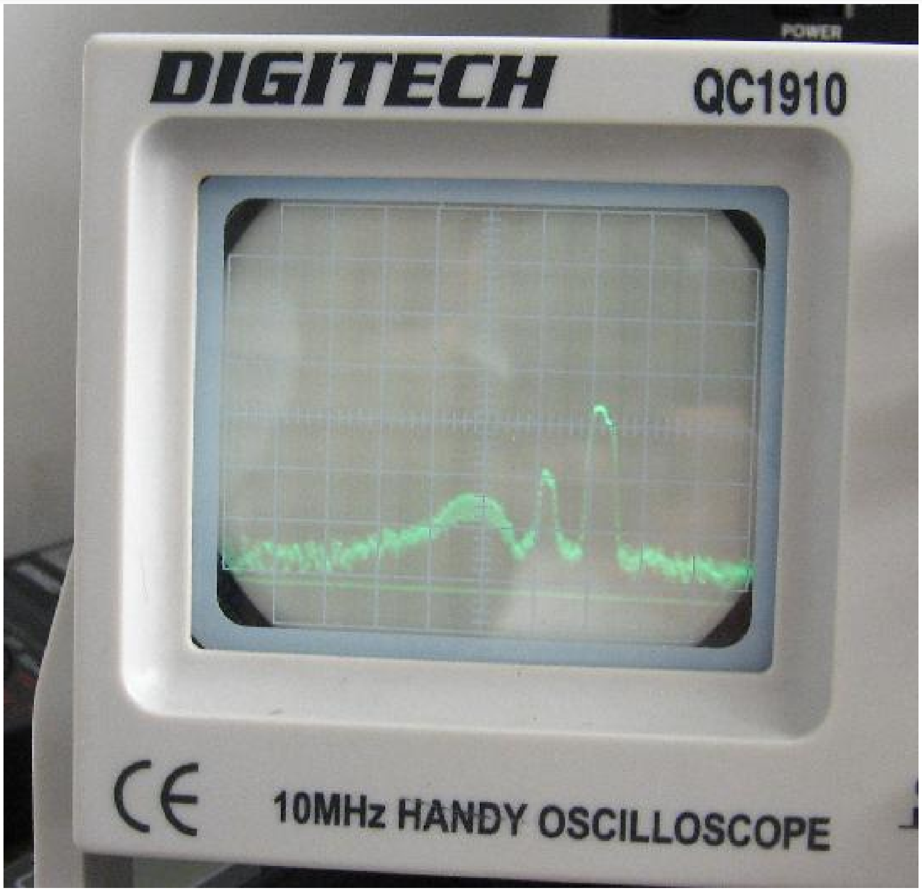
My hubris about "modern components" being superior and likely "purely capacitive" at VHF turned out to be completely wrong. It took *hours* to work it out, but eventually I determined the entire decoupling network was resonant near the operating frequency. Much foul language later and I replaced the cap with a ceramic 1 nF, with its "flashing" broken off and scraped right back to the disc to minimise the lead length. This cured the problem.

For the longest time I had assumed it was the source coil - and in fact the first source RFC I used (a molded choke) was being operated above its self-resonant frequency and prevented any oscillation at all. I replaced it with a few turns on a ferrite bead which seems just fine now.

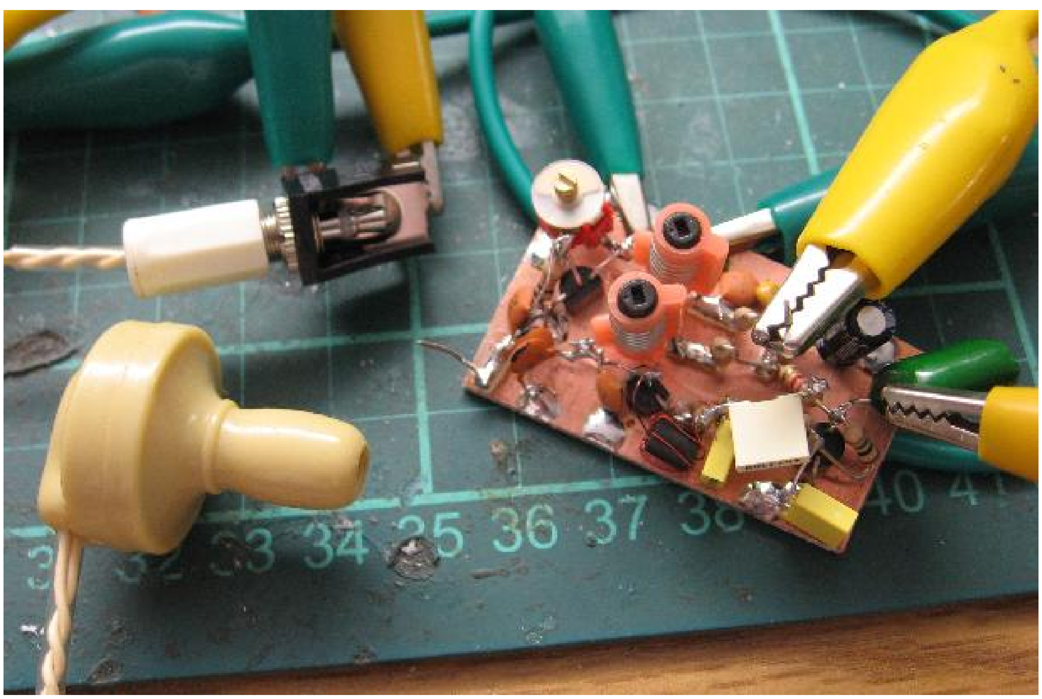
A couple of other minor annoyances/mistakes were worked through (like picking larger inductances and making the entire circuit so sensitive to stray capacitance it was a nightmare to tune - DUH!).



Eventually the unit super-regenerated right through the region of interest and the LNA stage was constructed. Initially I put the LNA drain coil too close to the detector coil and they over-coupled. This meant as I tuned through resonance on the LNA drain it would pull the detector so much it would shut down. Bugger! Moving the coils apart a little reduced this effect to acceptable levels, but the core of one still effects the other a little. I'm happy with the current coupling, and it is actually useful to help tuning the LNA resonator. As you rock it through resonance it will pull the detector, and by observing the wiggle on the spectrum analyser you can tell you've got it tuned up. The AGC action of the detector makes it hard to tune for maximum smoke otherwise, as the AF output doesn't change much at all even when the front-end isn't tuned up properly. Once you've got it nearly right you can use a weak signal to tune for best signal to noise.



Note the pagers above the 2 metre band in this spectrogram. The hump in the noise floor is the receiver super-regeneration side bands. The smaller peak in between is the output of the Fredbox transmitter, the leakage from the unshielded prototype on my desk operating into a 47 Ohm load. It is rather disturbing that the pager signals are *larger* than this local signal just a foot or two from the spectrum analyser antenna.



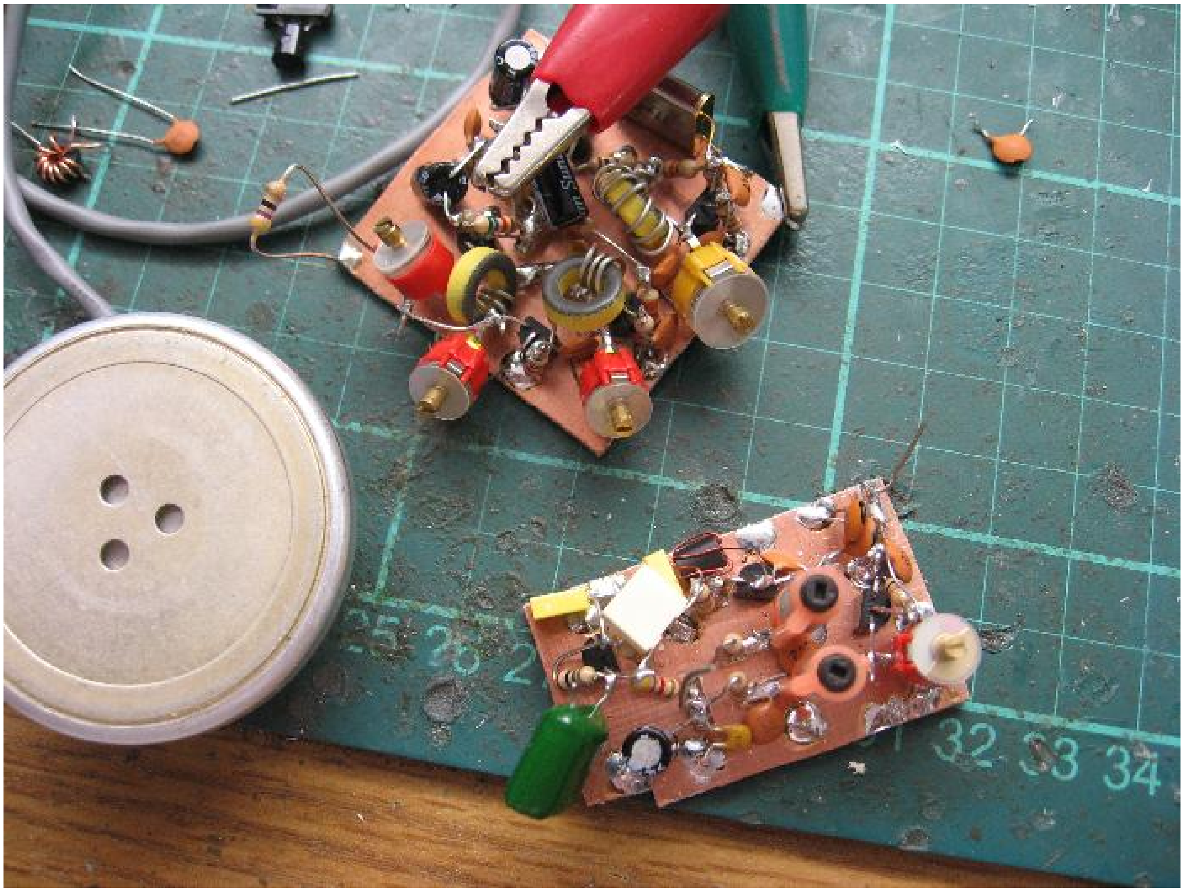
I used J310s for the receiver FETs, and a 2N3904 for the audio amp. Although the main design requirement for Roger appears to have been flea-power, I think a better AF amplifier that can drive modern low-impedance headphones would be preferable. Only Jaycar now carries crystal earphones with a nice soft silicone ear piece. The one I used comes from DSE and it is hard-plastic - not very nice on the ear. I really hate these kind of earphones anyway, I'll probably be rebuilding it for a low-Z output at some point, but it does work pretty well as-is.

BTW: While I was in the "Special Hell" of decoupling resonance I took the RX down to the FM broadcast band, and up to the VHF-hi TV band. It works wonderfully in both, which isn't a surprise. However, by adjusting the drain-source feedback (then a trimmer, now fixed) I

Hall's regen on the FM band. The topology is more forgiving however, allowing grounding of the tuning cap. I also built several different oscillator topologies in desperation before I identified the decoupling fault, in one I got a Colpitts-like oscillator working with emitter coupled feedback to a tapped capacitor across the tank. This is something I should have thought about a *long* time ago, I'll probably build yet another FM broadcast regen using this topology for the detector, it seemed quite easy to control just by manipulation of the base voltage.

Boxing It Up

I am still tossing up between a cast Aluminium box, a custom box folded out of Aluminium sheet, or an Altoids tin. The circuit is small enough to just fit inside an Altoids tin but it probably won't fit with a battery. I'll pick up a centre-off momentary-one-side switch over the next week and finish off the radio one way or the other.



Note the use of an old telephone receiver as the microphone. It is nearly as large as the entire TX board. I'll have to find my electret mics, I know I have a bag of them somewhere that I got from a Rockby sale.

I'm strongly considering rebuilding the radio, perhaps through-the-hole to minimise its size. Although my prototype isn't too large as-is, it would be nice to neaten it up. Maybe I'll build it with fixed caps and variable inductors to save space too, although shielded cans are about the same size. It *might* be possible to tune the multiplier stages with stretched coils and fixed caps, this would make it much more compact and save money too if it ends up being kitted...

More TX Power

I am considering running the unit on 12 Volts to get a bit more RF out, and perhaps building in a small amplifier to get it up to 1 Watt region. This would probably involve a rebuild of the TX side to use a 2N4427 or similar final device, and a more robust series modulator transistor. This won't be efficient, but is probably easier to get going than a linear amp which would need careful drive adjustment.

I'll probably conduct some experiments around using a 2N7000 or VN10KM as the output device. The math suggests they may operate on 2 metres. I've already got them working on 6 metres in a brief experiment last month (must document that).

Comments

Working with VHF is fun! I find it a great learning experience, especially when you get problems like the resonant decoupling cap. That kind of thing really pushes your understanding of the physics and teaches you a lot.

I know a lot of HAMs won't touch anything above the bandwidth of their oscilloscopes. I can understand the frustration when something doesn't work, especially when you can't see why, but it really isn't that much worse at VHF. With just a diode probe you can achieve a lot. It does help enormously if you have VHF test equipment, for example I likely would have never noticed the HF modulation problem had I not had a spectrum analyser (although the HF was visible on the collector of the modulator drive amp, and most of us have a CRO that can see fine near 16 MHz).

A wavemeter can be helpful, if a bit retro, especially for making sure your multipliers are tuned up right and for looking for spurs. You can build one quite easily, it only needs to be a resonator with a detector and a LED or meter as a read-out. I'm a big fan of the biased 1N5711 through the decoupled bottom of the tank coil topology. For super-sensitivity you can use a MPSA18 as a DC amplifier. With a signal generator or dipper and a counter or scanner/receiver you can easily calibrate it. It can be used like a poor-man's spectrum

My only advice when you get stuck is to trust the physics, do the math and follow your instinct when nothing is making sense. Rebuild parts of the circuit and test them independently. Measure what is actually happening and try to figure out what kind of misbehaviour in the circuit would cause the observed of behaviour. That will often solve an otherwise intractable problem.

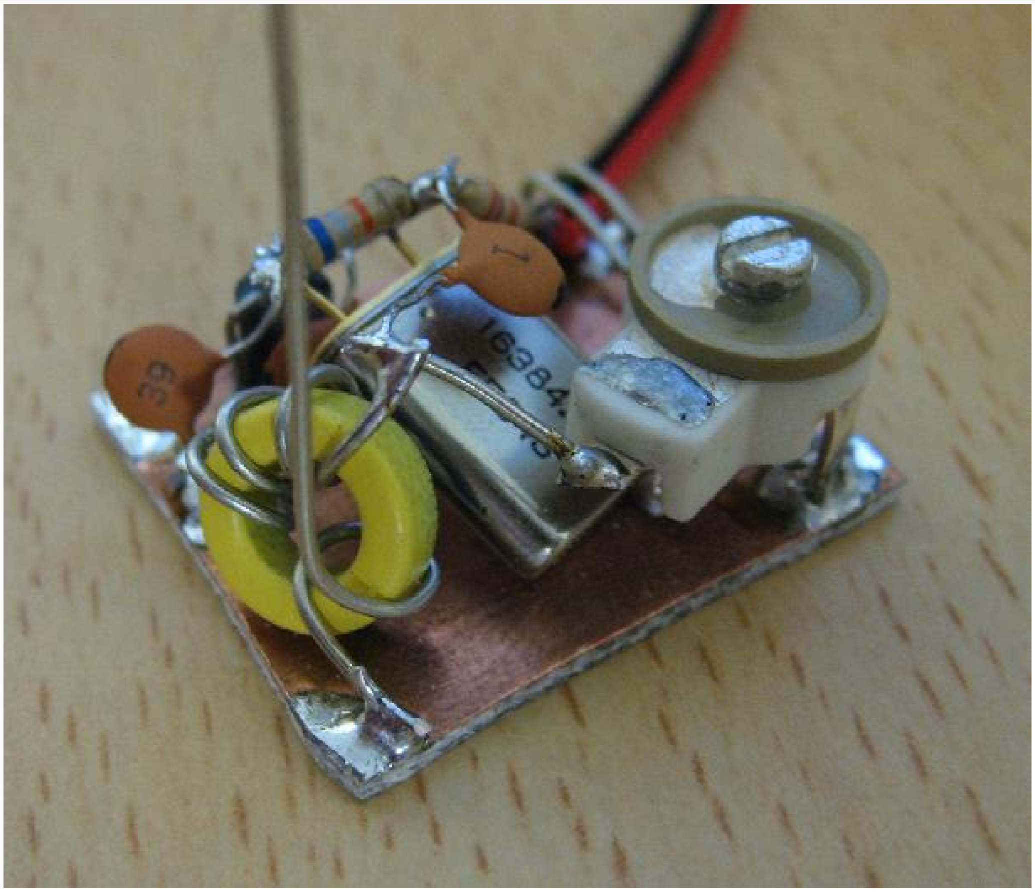
Update 2007-06-05

I took the Fredbox boards to the local Homebrew Group meeting. I had both halves hooked up and talking across the room. Peter VK2TPM had brought along a digital audio recorder and did an interview with many of us in attendance. You can hear what I said about The Fredbox on Soldersmoke 62, and even a brief snippet of audio going through The Fredbox.

Also on the recording are Peter VK2EMU talking about the 80 meter challenge, John VK2ASU talking about his transmitter modules for the challenge (and an interesting diversion into IRF510 gate-modulation with some input from Brian VK2TOX - something I was thinking about back here, apparently Drew Diamond VK3XU has already produced a design doing just this). Mike VK2BMR also talks about his great VSWR/power meter project. His unit was absolutely beautiful, I was very much taken by the excellent job he did of cutting the PCB stock that made up the external directional coupler box, essentially flawless, perfectly square workmanship.

Update 2007-06-09

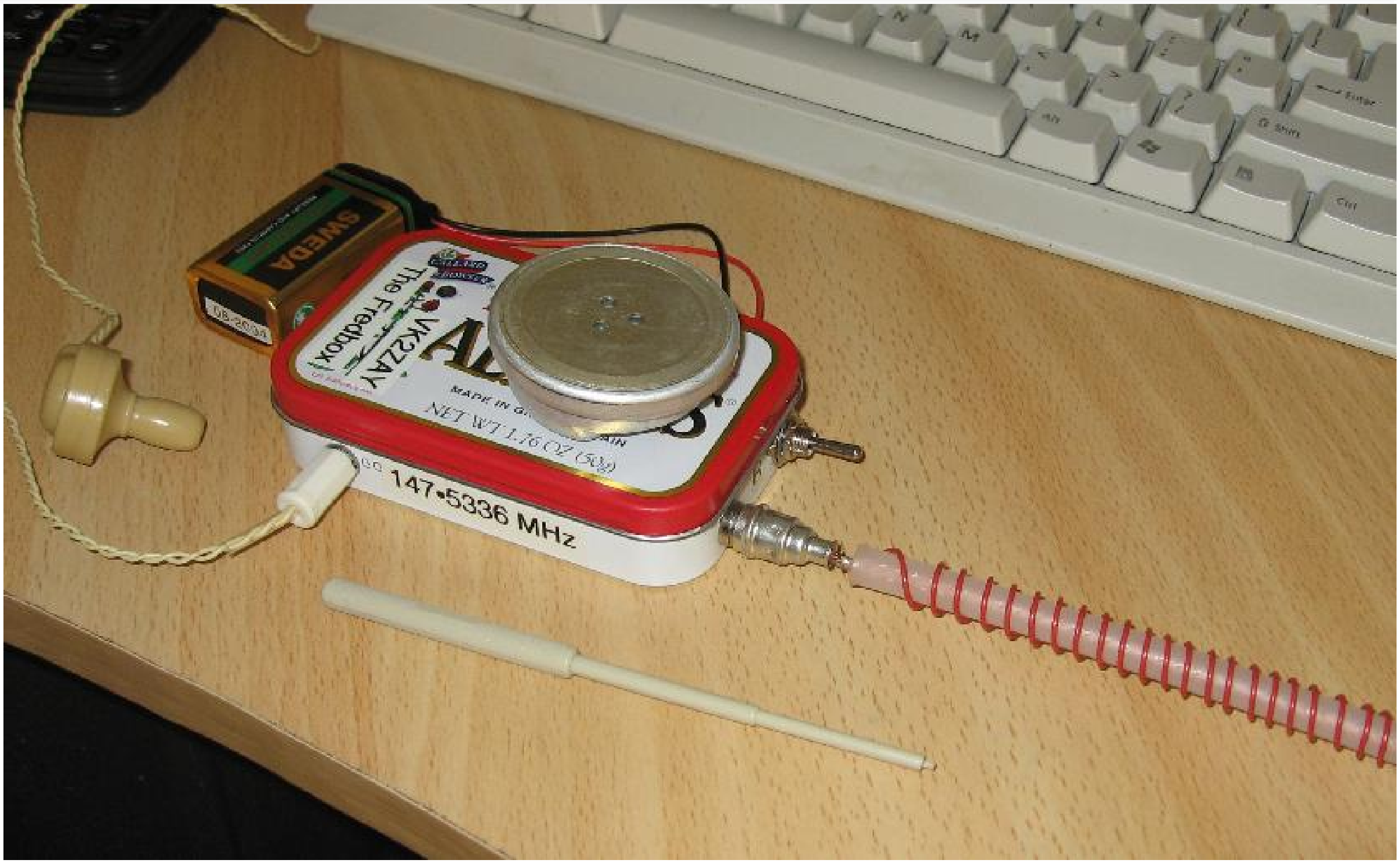
I've built a weak-signal source for aligning the receiver. One of the biggest weaknesses of the Fredbox receiver is that it drifts in frequency quite significantly with Vcc variations. Powered by a 9 Volt battery near the end of its life, it may drift enough to make the receiver completely off-frequency despite its poor selectivity. If I build this circuit again I'll probably put in a stabilized supply for the detector stage to avoid this problem.



The signal source is a Pierce oscillator driving a tuned circuit which selects the VHF harmonic of interest. Because of the oscillator topology the crystal isn't pulled down as much as in the Fredbox circuit. The difference is fairly minor for my purposes, the poor selectivity of the receiver makes the difference in frequency of no real consequence. There is no active (or passive) multiplier, so the tuned circuit is merely extracting the harmonic energy from the oscillator. The harmonic energy available is very small, which is perfect for the application, giving an almost undetectable signal 1 metre away.

Update 2007-06-10

I've boxed up the Fredbox. As discussed earlier I went with the Altoids tin, despite this not allowing the battery to also fit inside the enclosure. I tossed up soldering an additional tin to the back to hold the batteries, but for now I've gone with the 9-volt battery snap just hanging out. It will work well with 6xAA battery holders which can just be held to the box with a rubber band.



For the RF connector I chose an RCA. I can hear all the VHF engineers cringing, but for the purposes of this prototype it works just fine. The Antenna is a half-wave of wire helical which is quarter-wave resonant (with some pruning). The former is a piece of centre conductor and insulator from RG-213 coax. The centre conductor was left in place and is soldered into the RCA plug centre conductor, adding some capacitive loading and shortening the length of wire needed for resonance. I have no idea if this is good or bad, but it works.

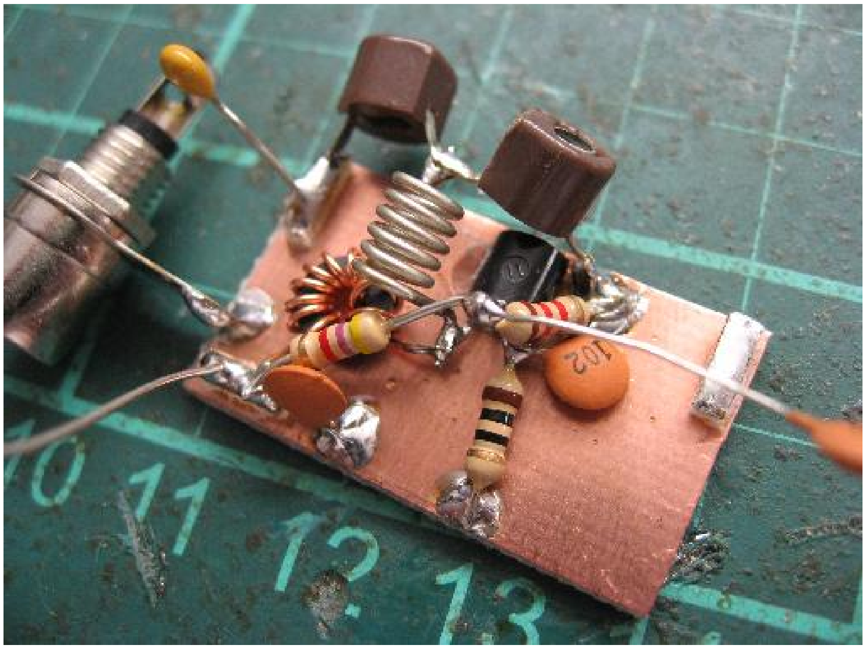
 XHTML | CSS | CSS toggle

I didn't find my stash of electret microphones, so I ended up just soldering the telephone receiver into the top of the Altoids tin. Ugly as hell, but also kinda unique. It looks somewhat like those Vietnam-war era VHF-low walkie-talkies.

I couldn't find a momentary-one-side toggle switch, so a centre-off on-both-sides switch was used instead. A special dummy load/diode peak-voltage probe was assembled for the final alignment. The carrier power ended up being near 25 mW on 12 Volts, on 9 Volts 10 mW just like Roger says in the article.

Update 2007-06-11

The 2N7000 on 2 metres experiment was a failure, it simply doesn't produce useful power beyond 90 MHz or so. However, it is very usable below 70 MHz. My input network was far from optimal, so perhaps with some more work it would be possible to get it working higher up, and I haven't tried an VN10KM in the same circuit.



I've also been fiddling around with grounded-base class-C multipliers. (Not just decoupled, biased base, the base actually soldered directly to the ground plane.) At first this seems a little weird, but if you pull the emitter low with a link-coupling to the previous stage collector current will flow. The advantage is excellent reverse isolation, which might help with stability with less than ideal layouts and devices. Such a topology was apparently quite common years ago with the 2N918.

1 comment.